Essential Science 3

Essential
Science

BOOK 3

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by Charles Windridge

illustrated by Trevor Stubley

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Author's note

We are living in an age of scientific discovery and achievement. To a large extent, our way of life is governed by machines and technical processes. Therefore, it is very desirable that, when youngsters leave school, they should possess that kind of scientific knowledge which will enable them to understand and appreciate the work of the scientist and its many everyday applications.

The books in this series provide a course in general science for children in secondary schools. Every effort has been made to ensure that the contents are interesting and attractive and truly relevant to the needs of the pupil. The illustrations are bold and colourful. The language used is simple and direct.

The practical work is straightforward and homely and can be performed with the simplest apparatus. This means that the books could be particularly useful in those schools where laboratory facilities are not available.

The written-work is at a minimum and consists of word lists, completing sentences, labelling drawings, brief descriptions, etc. It is felt that the traditional technique for writing-up experiments – apparatus, method, results and conclusions –, while suitable for pupils who are pursuing academic courses, is not suitable for the pupils for whom these books are intended.

Thanks are due to Mrs L. Allen for her help and Adhesive Tapes Ltd. for permission to mention their products.

C. WINDRIDGE

Important notice

This book, as with the other books in the series, has been fully "metricated and decimalized" in accordance with the Standard International System of Units (Le Système International d'Unitès), known, more simply, as SI, which has been adopted as the national measuring system in the United Kingdom.

Due consideration has been given to the recommendations of the British standards authorities – the British Standards Institution, the Royal Society, the Association for Science Education, the Royal Institute of Chemistry, etc.

Some of the many SI fundamental, derived and supplementary units are:

physical quantity	*unit*	*symbol*
length	metre	m
mass	kilogramme	kg
time	second	s
temperature (customary)	degree Celsius	°C
electric current	ampere	A
area	square metre	m^2
volume	cubic metre	m^3

Further information about SI units can be obtained from these publications:

Changing to the Metric System. Her Majesty's Stationery Office.
Metrication in Secondary Education. The Royal Society.
The International System (SI) Units. 3763. The British Standards Institution, Sales Branch, 101 Pentonville Road, London, N.1.
Physio-Chemical Quantities and Units. The Royal Institute of Chemistry.
SI Units, Signs, Symbols and Abbreviations. The Association for Science Education.

Contents

Author's note *page* 5
Contents 7
1 Electricity 8
2 Frictional electricity 10
3 Making electricity 12
4 How electricity travels 14
5 Conductors and insulators 16
6 Switch on the light 18
7 Heat from electricity 20
8 Danger! Electricity! 22
9 Electro-plating 24
10 Some electrical models 26
11 Magnets 28
12 More about magnets 30
13 Using magnets 32
14 Electro-magnets 34
15 Using electro-magnets 36
16 The sky at night 38
17 Finding the way 40
18 The earth's family 42
19 Sunshine and shadows 44
20 "The man in the moon" 46
21 What's the time? 48
22 Cold-blooded animals 50
23 The story of the frog 52
24 The force of gravity 54
25 Weight 56
26 The centre of gravity 58
27 Escape into space 60
28 Copying the birds 62
29 Flying machines 64
30 A model glider 66
31 Soil 68
32 "The little ploughman" 70
33 Seeds 72
34 Germinating seeds 74
35 How plants grow 76
36 Plants without flowers 78
Index 80

1 Electricity

Electricity is important

Think about the many things that are operated by electricity. Then you will understand why electricity is so important to us. It drives our trains and machinery, heats and lights our homes, cooks our food and makes possible many kinds of entertainment – television, radio, record players, etc.

Electricity is energy

But, what is electricity? You cannot see it and you cannot hear it, yet it is very real. You can certainly feel it, as you well know if you have ever had an electric shock. Electricity is a kind of *energy*. It can be changed into other kinds of energy, such as heat and light.

Most of the electricity we use is made in *power-stations*. It travels along wires to the places where it is needed to heat radiators, fires and cookers, light lamps and drive the motors of vacuum cleaners, hair dryers, fans, etc.

Electric charges

Electricity was first discovered about 2500 years ago. The Greek ladies of that time wore *amber* beads. Amber is a very hard gum from certain trees. They found that if they rubbed the beads with fur, hair or wool, the beads would attract and pick up fluff, dust and small bits of straw. The beads had been given *electric charges*.

Since then, it has been found that other things, such as glass, wax and bone, are given electric charges if they are rubbed with certain materials. These charges are not useful. They cannot light lamps or drive machinery.

Making electric charges

Rub the bottom of a glass tumbler with a piece of silk. Hold the bottom of the tumbler near to some small pieces of wool. They cling to the tumbler.

Rub a stick of sealing wax on fur. Pick up small pieces of paper with the stick of sealing wax.

Lightning and thunder

Sometimes, and in a way that we do not quite understand, clouds become charged with electricity. When a cloud is heavily charged, some of its electricity flows through the air to the earth or to another cloud. The air heats up and glows. This is *lightning* – large electric sparks. *Thunder* is the noise made by the heated air as it expands and moves quickly.

Lightning conductors

Tall buildings are protected from lightning by *lightning conductors*. A lightning conductor is a thin strip of copper through which lightning can flow to the earth without doing any damage.

Lightning is electricity

Over 200 years ago, Benjamin Franklin, an American scientist, showed that lightning is electricity. He flew a kite during a thunderstorm. Electricity from the clouds flowed down the wet string and charged a key tied on a silk ribbon.

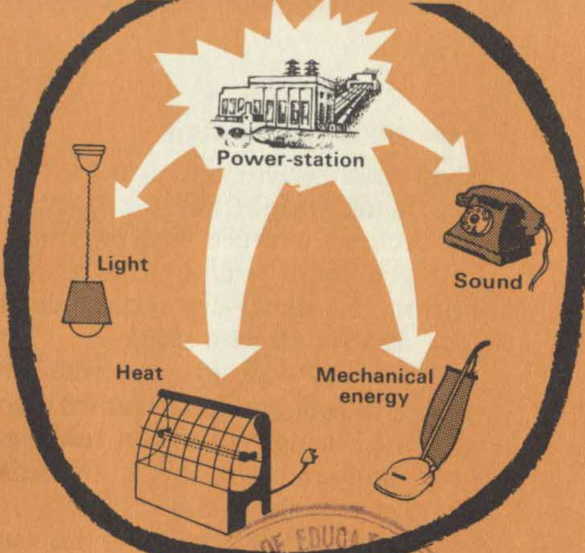
MORE THINGS TO DO

1. Make a list of the things in your own home that are operated by electricity.
2. Write a few sentences about electric charges, lightning and thunder.
3. Draw a church with a lightning conductor.

Electricity

All these things are operated by electricity

ELECTRICITY IS ENERGY



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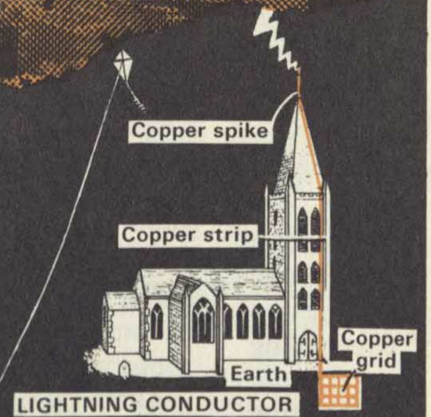
BENJAMIN FRANKLIN SHOWED THAT LIGHTNING IS ELECTRICITY



LIGHTNING CONDUCTOR

MAKING ELECTRIC CHARGES

2 Frictional electricity

Electricity by rubbing

Sometimes, when you stroke a cat, its fur stands upright. This is because its fur becomes charged with electricity.

If you comb your hair in front of a mirror in a dark, dry room, you may hear and see electric sparks.

When you pull off your vest before you go to bed, you may hear the crackle of sparks made by the vest rubbing on your hair and causing it to become charged with electricity.

Electricity that is made in this way is called *frictional electricity*. *Friction* is the rubbing together of two surfaces.

You cannot charge a piece of metal with electricity by rubbing it. The electric charges on its surface flow through it and away into your hand.

Some experiments with frictional electricity

1. Rub the end of a plastic fountain pen briskly on a woollen cloth. Touch some small pieces of paper with the end of the pen. The pieces of paper cling to the pen. Why?

2. Rub the end of a steel knitting needle on a woollen cloth. Touch some small pieces of paper with the end of the needle. The pieces of paper do not cling to the needle. Why?

3. Brush a sheet of brown paper with a dry clothes brush. Hold the paper over a boy's head. Some of his hair stands on end. It is attracted by the electric charges on the brown paper.

4. Rub a plastic pen on a woollen cloth. Hold a postage stamp upright with your fingers. Lower the pen so that it is just above the stamp. Remove your fingers and the stamp stands upright without any visible support. What is supporting the stamp?

5. Blow up a balloon and then rub it on a woollen cloth. Hold the balloon against a wall. Remove your hand. The balloon clings to the wall. Why?

A simple electricity machine

Cut out a piece of an old cycle inner tube and lay it on a table. Hold it down with drawing pins. Heat the end of a stick of sealing wax and then press it firmly on to the inside of a metal lid.

Rub the piece of inner tube with fur or a woollen cloth for about a minute. The rubber becomes charged with electricity. Use the sealing wax as a handle and press the lid, outside downwards, on to the rubber. Then, raise the lid. Bring the end of one of your fingers close to the lid. A spark flashes between your finger and the lid.

This electricity machine works best when the air is very dry.

Making an electroscope

An instrument for detecting electric charges is called an *electroscope*. Make a simple electroscope in the way shown opposite.

Rub a plastic pen on a woollen cloth and bring it close to the paper ball. What happens to the ball?

MORE THINGS TO DO

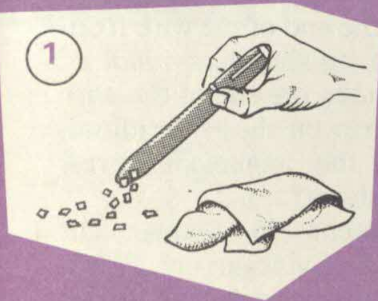
1. Draw a simple electroscope. Label its parts.

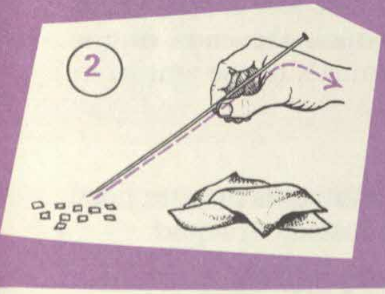
2. Make freehand drawings of *two* of the frictional electricity experiments.

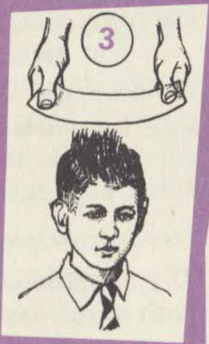
3. Make an "electric snowman" in the way shown opposite. You can do this at home.

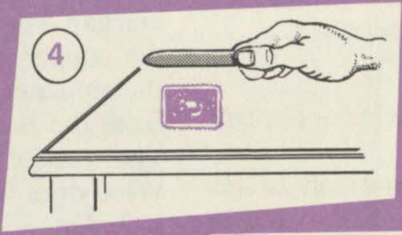
Frictional electricity

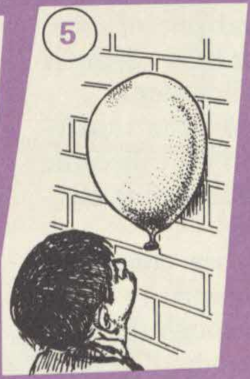
SOME EXPERIMENTS WITH FRICTIONAL ELECTRICITY



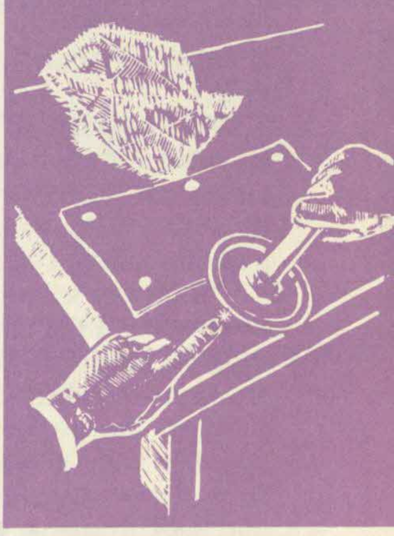




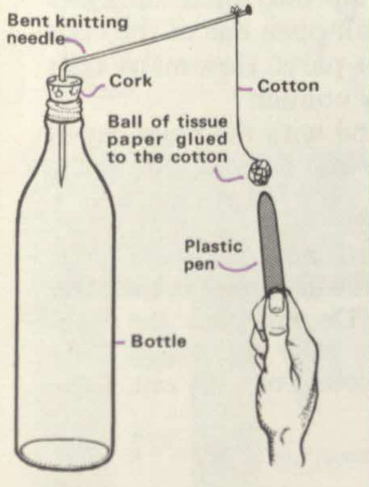




SIMPLE ELECTRICITY MACHINE

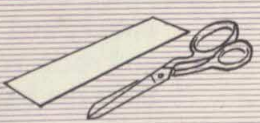


MAKING AN ELECTROSCOPE

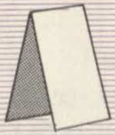


The charged pen attracts the ball of paper

MAKING AN "ELECTRIC SNOWMAN"

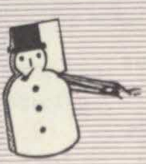


1. Cut out a piece of thick paper about 12 cm. long and 2 cm. wide.



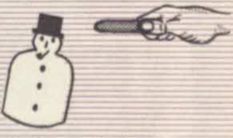
2. Fold the paper into two.

3. Draw a snowman on one side of the paper.



4. Cut out the snowman. Cut a curve at the bottom. Do not cut the top of the hat.

5. Open the paper a little and stand the snowman upright. He should rock when you touch him.



6. Rub the end of a fountain pen with fur or wool. Bring the end of the pen close to one side of the snowman. What happens to the snowman?

3 Making electricity

Electric batteries

The electricity that we use to operate portable electrical equipment, such as transistor radios, torches, bicycle lamps, etc., is made by *batteries* which are carried about with the equipment.

Electric cells

A battery contains two or more *electric cells*.

The first kind of electric cell to be invented is shown opposite. Two metal strips, one of *copper* and one of *zinc,* dip into a dish of acid or *brine*. Brine is a strong solution of salt in water.

The copper strip is called the *positive electrode* and the zinc strip is called the *negative electrode*. Sometimes, the electrodes are marked + and −.

When the electrodes are connected together with a wire, electricity flows from the − electrode through the wire and back to the + electrode. If several of these cells are connected together, they will give enough electricity to light a small lamp.

A simple electric cell

Make a simple electric cell.

Use paper clips to attach bare copper wires to a strip of copper and a strip of zinc. Place the strips in a jar of *dilute sulphuric acid.* The strips must not touch.

Wrap the end of one of the wires around the screwed part of a 1½ *volt* torch bulb. Touch the metal stud on the bottom of the bulb with the end of the other wire. The bulb lights. Why?

Touch the strips together. What happens?

Some experiments with cells

For these experiments you will need an *ammeter*. An ammeter is an electrical instrument which can detect small amounts of electricity that would not be large enough to light a torch bulb. (Teacher: use an ammeter which shows a full scale reading of 0·1 milliamperes.)

1. Place the copper and zinc strips from the last experiment in a jar of vinegar. Touch the end of the wire from the copper strip on the + *terminal* of the ammeter. Touch the end of the wire from the zinc strip on the − terminal. The needle of the ammeter moves. What does this show?

2. Do experiment No. 1 again but use brine instead of vinegar.

3. Cut two slits in a lemon or an orange. Push the zinc and copper strips into the slits. Touch the ends of the wires on the terminals of the ammeter. What happens?

Dry batteries

Dry batteries contain cells that are filled with moist paste instead of liquid.

The parts of a dry cell

Perhaps your teacher will remove the outer case of an old torch or cycle battery and break open one of the cells and show you its parts. How many cells does the battery contain?

The carbon rod with the brass cap is the + electrode and the zinc case is the − electrode.

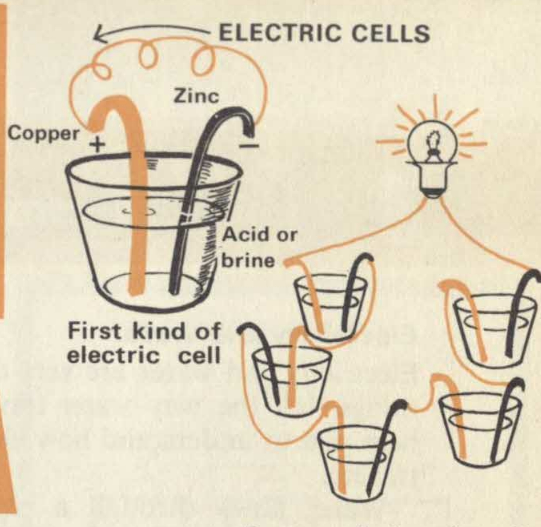
MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite. Do not draw the black frame.

2. Draw the section of a dry cell. Label the parts.

Making electricity

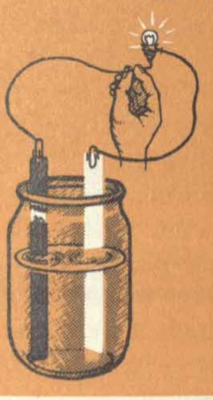
These things are operated by batteries

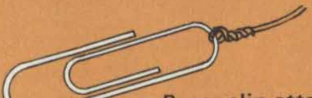


First kind of electric cell

Battery of electric cells

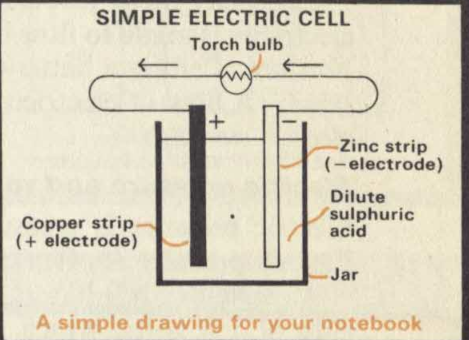
SIMPLE ELECTRIC CELL





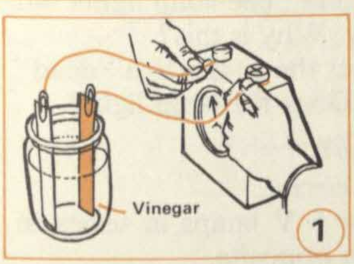
Paper clip attached to a wire

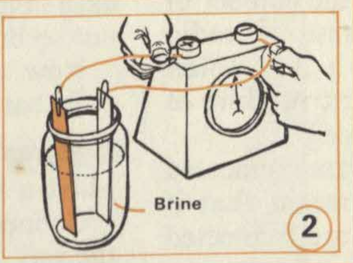
Torch bulb attached to a wire

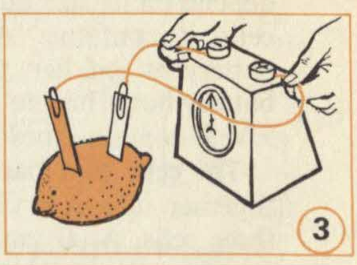


A simple drawing for your notebook

SOME EXPERIMENTS WITH CELLS

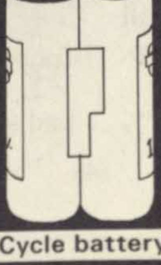




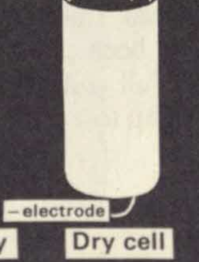


DRY BATTERIES

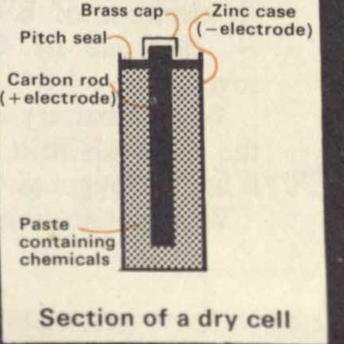
Torch batteries



Cycle battery



Dry cell



Section of a dry cell

4 How electricity travels

Electricity and water

Electricity and water are very different things, but the way water travels will help you to understand how electricity travels.

Water flows through a pipe. The water is made to flow by the *head of pressure*.

Electricity flows through a wire. The electricity is made to flow by the *electric pressure* of either a battery or the *mains supply*. A flow of electricity is called an *electric current*.

Electric pressure and voltage

Electric pressure is measured in *volts*. Electric pressure is often called *voltage*.

A single dry cell has an electric pressure of 1·5 volts, which, for short, is written as 1·5 V. The electric pressure of the mains supply is usually 240 V.

The voltage of a battery does not depend on its size but on the number of cells it contains. A transistor radio battery is smaller than a 3 V torch battery but it has an electric pressure of 9 V. It contains six 1·5 V cells.

The cells in a battery are connected together in series. This means that if three cells, A, B and C, are connected together, the + electrode of A is connected to the − electrode of B and the + electrode of B is connected to the − electrode of C. The three cells together give 4·5 V.

When a battery is "dead", nearly all the chemicals in it have been used up. It will no longer give its full voltage.

When connecting a lamp to a battery, make sure that the lamp is of the correct size. The voltage marked on the lamp must be the same as that of the battery. A 9 V battery would damage a 1·5 V lamp. The electric pressure of a 3 V battery is not large enough to light a 20 V lamp.

Looking at batteries

Examine some different kinds of dry batteries.

Look at the voltages marked on them. What is the voltage of a cycle battery?

A simple electric circuit

Make a simple *electric circuit*.

Use a small screwdriver to connect a switch to a lamp-holder. Use paper clips to fasten the spare ends of the wires on to the terminals of a 6 V cycle battery. Screw a 6 V lamp bulb into the holder.

Press the switch to the "on" position. The lamp lights. Press the switch to "off". The lamp goes out. Why?

The lamp will light only when there is a metal circuit by which an electric current can flow from the − terminal to the + terminal of the battery.

Then, connect the circuit to a 4·5 V flash-lamp battery. The lamp lights but not so brightly. Why is this?

Now, connect the circuit to a "dead" cycle battery. Does the lamp light?

A series circuit

Make a *series circuit*.

Connect two 6 V lamps in series in the way shown opposite.

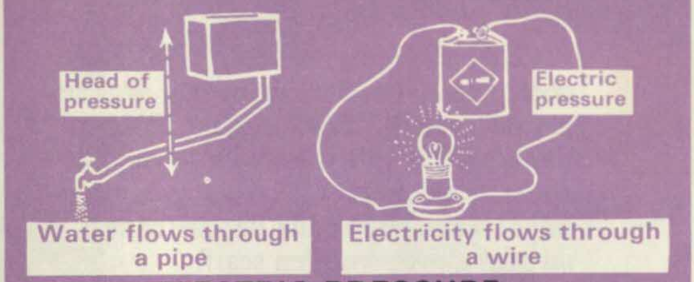
Press the switch to "on". The lamps light but they are dim. The two lamps share the electric pressure of the battery.

MORE THINGS TO DO

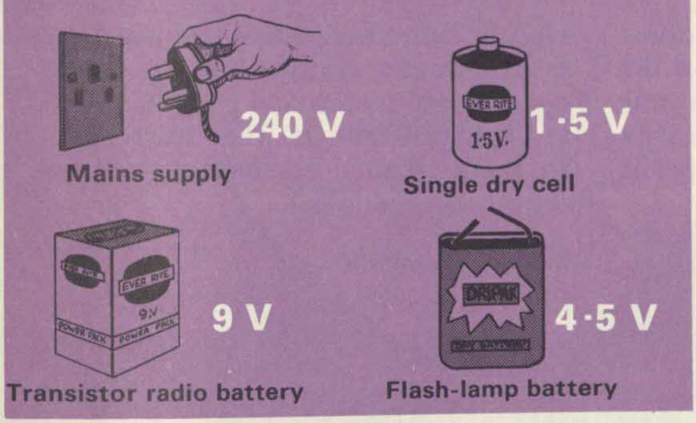
1. Copy the drawings shown in the black frames opposite.
2. Work out the total voltage of (*a*) 16 and (*b*) 21 dry cells connected in series.

How electricity travels

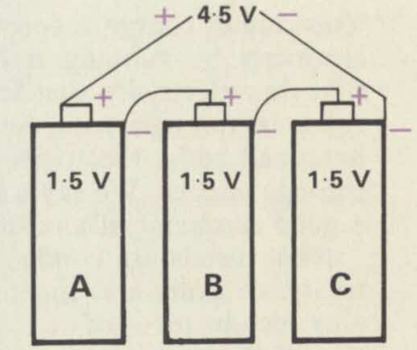
ELECTRICITY AND WATER


Head of pressure
Electric pressure
Water flows through a pipe
Electricity flows through a wire

ELECTRIC PRESSURE

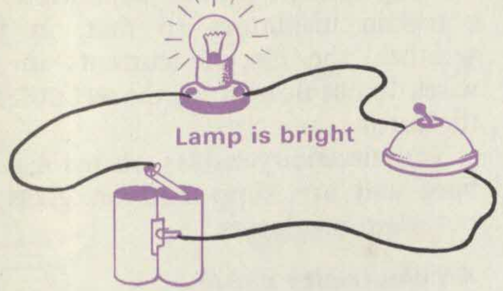


CELLS IN SERIES

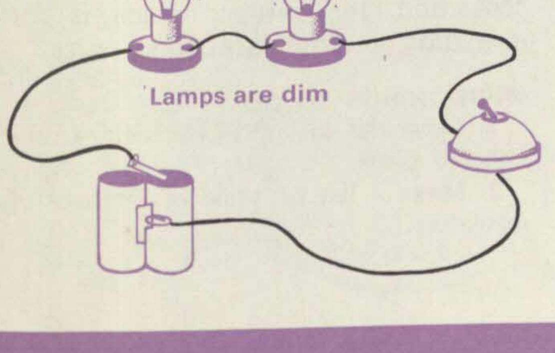


The cells in a battery are connected together in series

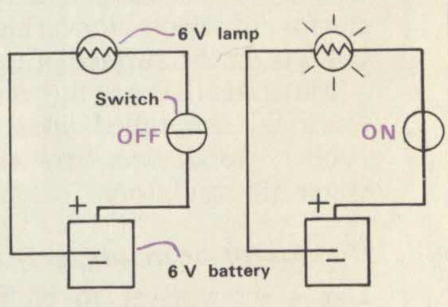
SIMPLE CIRCUIT



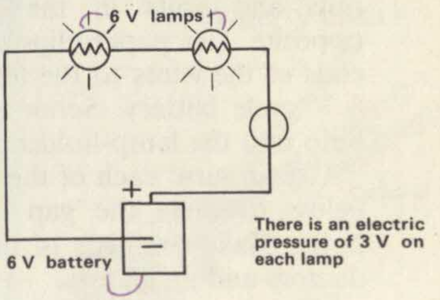
SERIES CIRCUIT



SIMPLE CIRCUIT



SERIES CIRCUIT



A simple drawing for your notebook

5 Conductors and insulators

Conductors

You cannot charge a copper rod with electricity by rubbing it on wool or silk. Any electricity that forms on the rod flows through it and away into your hand and body. Electricity flows easily through copper. We say that copper is a good *conductor* of electricity.

Most metals are conductors of electricity. *Graphite* and impure water are also conductors of electricity. The "lead" of a pencil contains graphite. A pencil "lead" is not made of lead.

Insulators

You can charge a plastic fountain pen with electricity by rubbing it on fur or wool. The electricity that forms cannot flow away because plastic is not a conductor of electricity. This electricity collects on the surface of the pen.

Materials that are not conductors of electricity are called *insulators*. Glass, rubber, wood, wax, dry air and pure water are insulators.

Conductor or insulator?

Use a screwdriver to connect copper wires to a lamp-holder and two sets of nuts and bolts in the way shown opposite. Use paper clips to fasten the ends of the wires to the terminals of a 6 V cycle battery. Screw a 6 V lamp bulb into the lamp-holder.

Use, in turn, each of the things listed below to close the gap between the bolts. Make two lists of things – conductors and insulators.

Cork; sixpence; candle; string; key; comb; nail; brass screw; penny; rubber; cotton; pencil "lead"; glass tumbler; paper; jar of salt water; jar of distilled water; match-stick; coke; gold nib; bone; sealing wax; silk tie; earthenware jar; fur glove; woollen scarf.

Using conductors

Electric currents must be able to flow easily through electricity cables, telegraph wires, switch and lamp *contacts* and battery terminals. That is why they are made of good conductors, such as copper, brass or steel.

Using insulators

Electrical equipment and wires are covered with insulation to prevent any loss of electricity and to safeguard people against electric shocks.

Switches, *plugs, bell-pushes, ceiling roses,* etc. have plastic covers.

Cables are insulated with enamel, rubber and fabric.

Telegraph wires are supported on porcelain insulators so that, in wet weather, the electric currents in the wires do not flow down the wet poles to the earth.

The electricity cables on pylons are bare and are supported on glass or porcelain insulators.

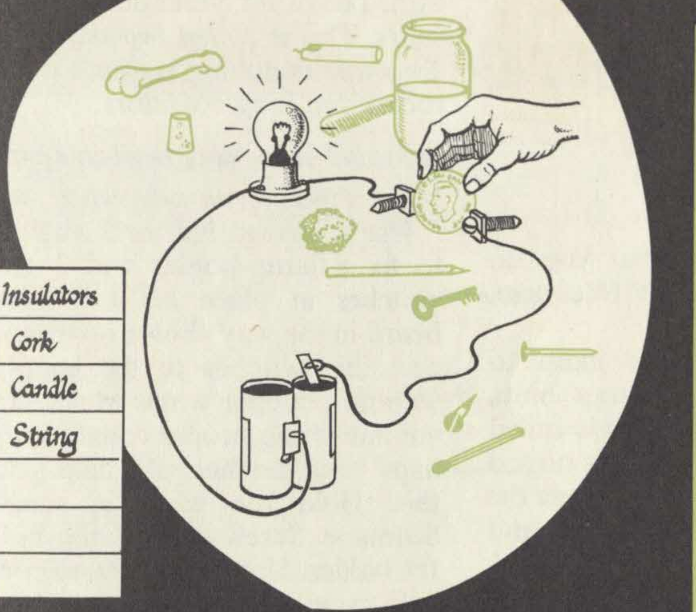
An electricity cable

Examine the end of an electricity cable that is *not connected to the mains supply*. Look for the outer fabric, which is for protection, the rubber, which is for insulation, and the bare copper wires.

MORE THINGS TO DO

1. Draw the end of an electricity cable. Label its parts.
2. Make a list of some of the uses of insulators.

Conductors and insulators



Conductors	Insulators
Sixpence	Cork
Key	Candle
Nail	String

CONDUCTORS

Copper
Graphite
Impure water
Brass
Steel
Iron
Aluminium
Silver
Gold
Tin
Zinc
Magnesium
Mercury
Coke

INSULATORS

Wool
Cotton
Silk
Fur
Glass
Rubber
Wood
Paper
Plastic
Dry air
Pure water
Cork
Candle wax
Sealing wax
Leather
Bone
Earthenware
Porcelain
String

USING INSULATORS

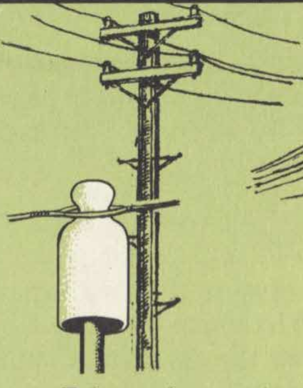
Switch

Plug

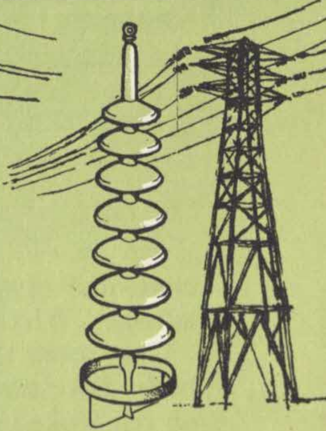
Bell-push

Ceiling rose

Pliers with insulated handles



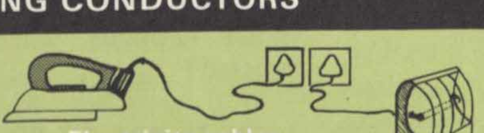
Telegraph insulators



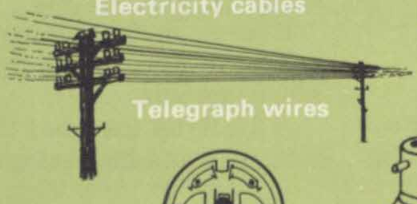
Electricity pylon insulators

USING CONDUCTORS

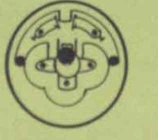
Battery terminals



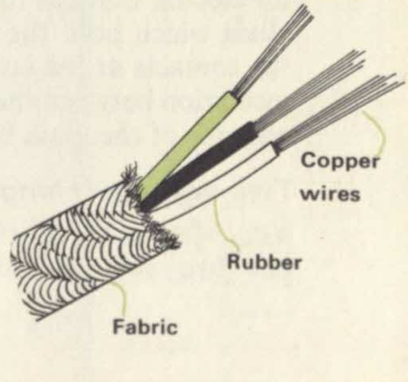
Electricity cables



Telegraph wires



ELECTRICITY CABLE



6 Switch on the light

Electric lamps

What is the first thing that you do when you enter a dark room? Of course, you switch on the light.

What causes an electric lamp to shine? Inside an electric lamp bulb, there is a very thin wire which is called the *filament*. When the switch is turned on, an electric current flows through the filament. It becomes white-hot and gives out much bright light. The filament is made of a special metal which does not melt when it becomes very hot. The bulb is filled with *nitrogen* gas. If it contained air, the filament would burn away.

A *fluorescent lamp* does not have a filament. It is filled with a gas which glows brightly when an electric current flows through it.

The parts of an electric lamp bulb

Wrap an old 240 V lamp bulb in a cloth and give it a sharp tap with a hammer. Why must you use a cloth?

Take away the cloth and examine the bulb. *Take care not to cut your fingers on the broken glass.* Look for the filament, the glass stem which supports the filament, the lead-in wires which carry an electric current to the filament, the studs which hold the lamp in a socket, the contacts at the end of the lamp, the insulation between the contacts, and the remains of the glass bulb.

Two-way switching

Very often, on a stairway, a single lamp has two switches so that it can be turned on or off either downstairs or upstairs. This is *called two-way switching*. Two-way switching is also used in bedrooms and long corridors.

A model two-way switch circuit

Make a model *two-way switch circuit*.

Use a screwdriver and small screws to fix a lamp-holder and 2 two-way switches in place on a flat wooden board in the way shown opposite. Connect the switches to the lamp-holder with thin copper wires. Make sure that you make the proper connections. Perhaps your teacher will help you with this. Hold the wires in place with Sellotape. Screw a 6 V lamp bulb into the holder. Use paper clips to connect a 6 V cycle battery to the circuit. Use both switches to turn the lamp on and off. Do you understand how the model works? Can you see why special two-way switches must be used?

An electric torch

A section drawing of an electric torch is shown on the page opposite. Look at it carefully. Can you see how a torch works? You notice that the metal case is a part of the circuit to the lamp.

The parts of a torch

Take a torch to pieces. Examine the parts. What is the purpose of the contact spring?

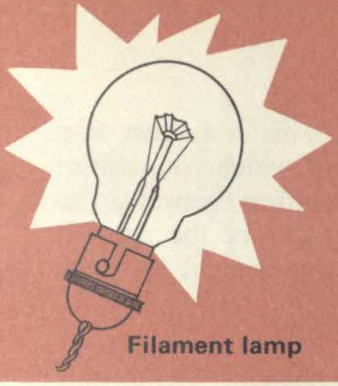
Put the parts together again.

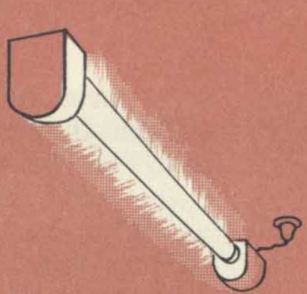
Operate the switch several times. What happens when the switch is pressed?

MORE THINGS TO DO

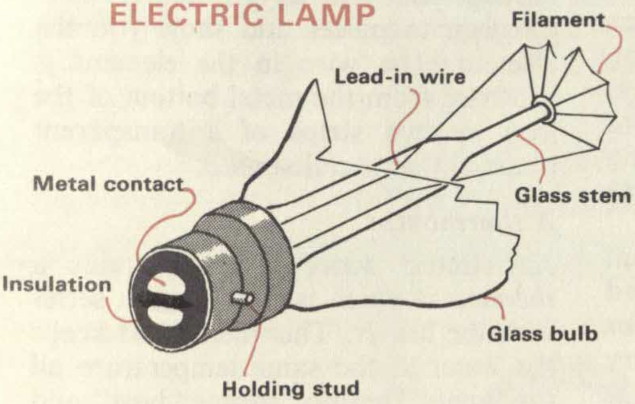
1. Draw an electric lamp. Label its parts.
2. Copy the drawing shown in the black frame opposite.
3. Look up the word "fluorescent" in a dictionary and find out what it means.

Switch on the light

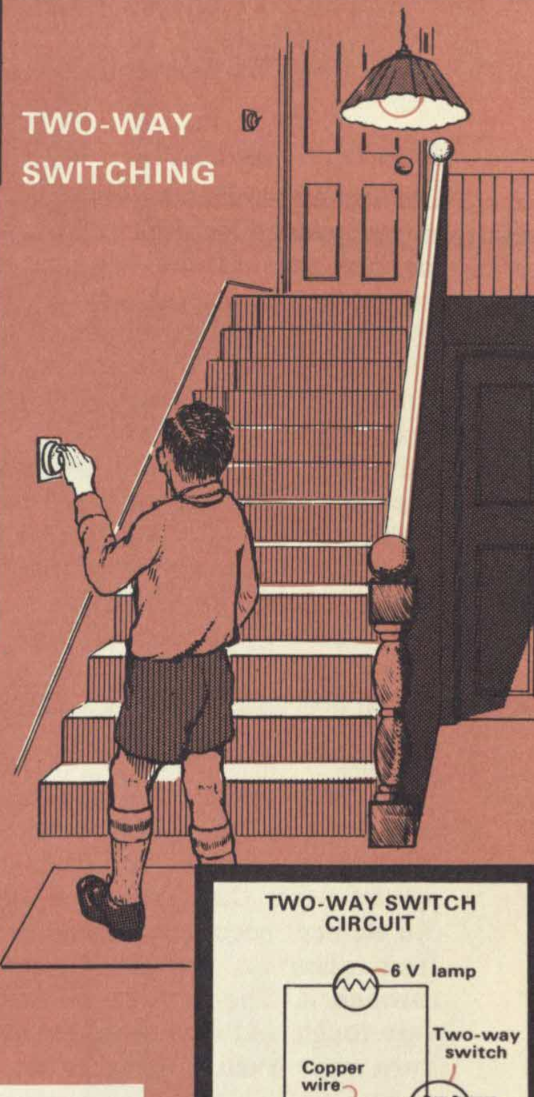

Filament lamp


Fluorescent lamp

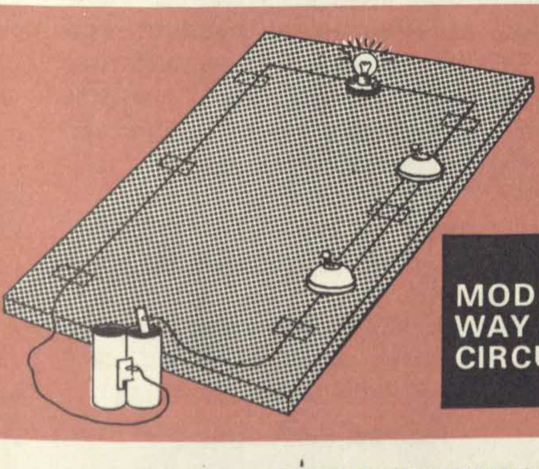
ELECTRIC LAMP



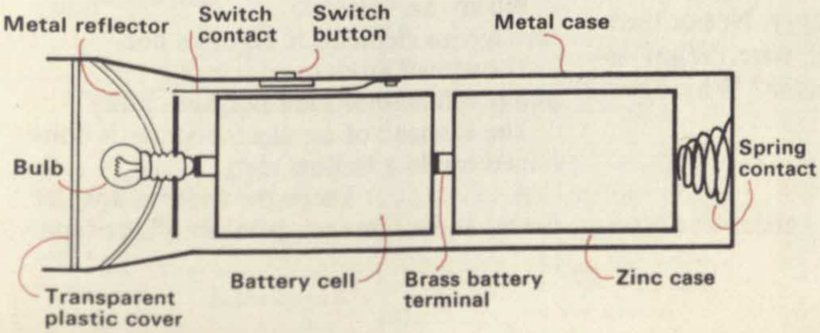
TWO-WAY SWITCHING



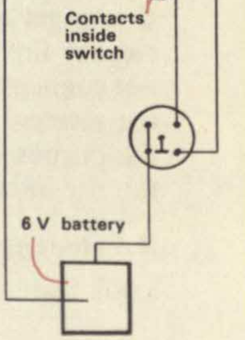
MODEL TWO-WAY SWITCH CIRCUIT



ELECTRIC TORCH



TWO-WAY SWITCH CIRCUIT



A simple drawing for your notebook

7 Heat from electricity

Heat from electricity

Connect a switch to a lamp-holder with copper wires. Use paper clips to fasten the free ends of the wires on to the terminals of a 6 V cycle battery. (Teacher: a 6 V accumulator is more suitable for this.) Join the connecting screws on the lamp-holder with about 5 centimetres of thin iron wire.

Press the switch to the "on" position. The iron wire becomes red-hot and glows. Do *not* keep the switch on for more than a few seconds or the battery will run down very quickly.

Switch on an electric table lamp. When it has been on for a few minutes, switch it off. Feel the lamp. Is it warm?

Using heat from electricity

Such things as electric radiators, fires, cookers, washing machines, water heaters, toasters, kettles and irons contain special wires that are called *elements*. An element becomes hot and gives out heat when an electric current flows through it. The wire of an element is very tough and it will neither melt nor burn away when it becomes hot.

An electric fire

If you get an opportunity, examine an electric fire. Make sure that the fire is not connected to the supply. Notice that the element is a coil of wire. What is the purpose of the *reflector*? Why does the fire have a *guard*?

An electric kettle

Look inside an electric kettle. Can you see a metal ring? This is hollow and contains the element which you cannot see. There is insulation between the element and the inside of the ring. It would not do for the element to touch the ring. Why?

An electric iron

Perhaps your teacher will take an electric iron to pieces and show you the element. The wire in the element is insulated from the metal bottom of the iron by two strips of a transparent material that is called *mica*.

A thermostat

An electric water heater contains a *thermostat* which is connected in series with the heater. This thermostat keeps the water at the same temperature all the time. "Thermo" means "heat" and "stat" means "steady". When the water is hot, the thermostat operates and switches off the heater. When the water begins to cool, the thermostat operates again and switches on the heater. In this way, no electricity is wasted.

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Draw an electric fire. Label the parts.
3. Copy these sentences, filling each space with a suitable word.

Heat from Electricity

Electric radiators, fires, cookers, washing machines, water heaters, toasters, kettles and irons contain ....

When an electric .... flows through an element, it becomes hot.

The wire of an element is very .... and it will neither melt nor burn away.

The element of an electric kettle is contained inside a hollow metal ....

A .... keeps the water in a water heater at the same temperature all the time.

Date 29.8.05
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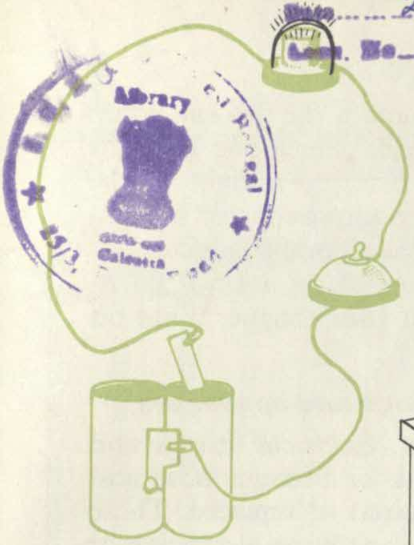
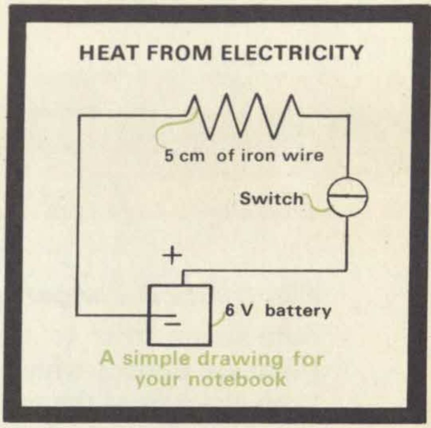
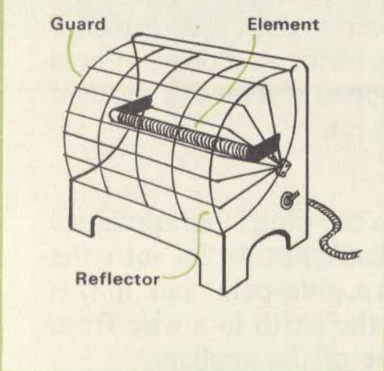




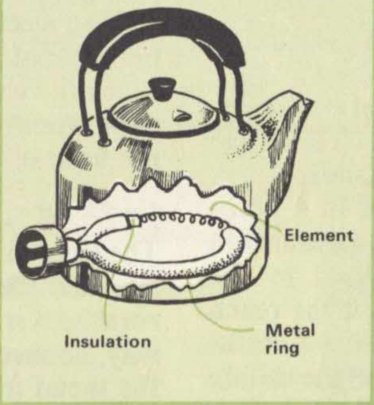
A simple drawing for your notebook

Heat from electricity

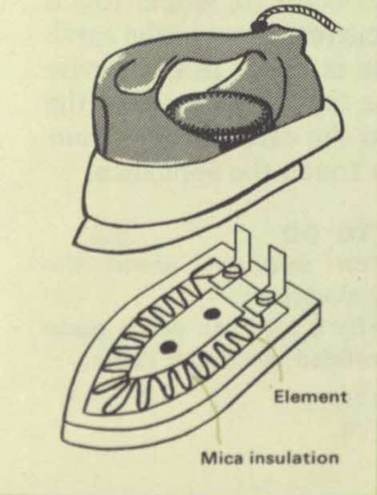
ELECTRIC FIRE



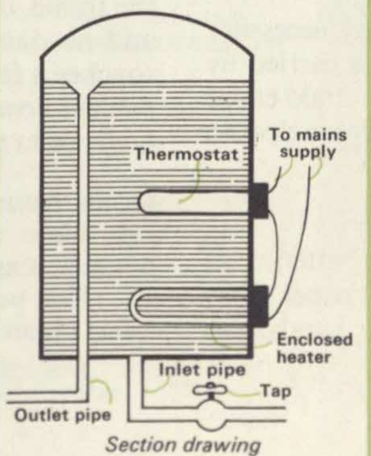
ELECTRIC KETTLE



ELECTRIC IRON



ELECTRIC WATER HEATER



Section drawing

8 Danger! Electricity!

Electricity is dangerous

Sometimes, near to electricity pylons, there are notices which warn people to keep away from the pylons. The pylons support cables which carry high voltage electricity. This electricity is dangerous.

In the experiments with electricity that you have done so far, you have been told to use batteries. You have *not* been told to use the mains supply because it might give you a shock that could kill you.

You must not use the mains supply for any of your experiments.

Water is a conductor

Water is a good conductor of electricity, and so it is dangerous to touch electrical equipment with your wet hands.

Plug-points are not fitted in a bathroom. The lamp fittings in a bathroom are usually covered and fixed to the ceiling where they are out of the reach of the people using the bath. A bathroom *safety-switch* is fixed to the ceiling and has a long cord which, when pulled, operates the switch. Portable appliances, such as hair dryers, should *not* be used in a bathroom.

These precautions are very necessary because the electricity that is carried by even a thin film of moisture could cause a person to be given a dangerous electric shock.

Electric shocks

Connect three 6 V cycle batteries in series with copper wires and paper clips. Hold the end wires in your hands. Do you feel a shock?

Now, place each of the two end wires in a dish of water. Place one hand in each dish. You may feel a slight shock.

Dry skin is a poor conductor of electricity; wet skin is a good conductor.

Hold the terminals of a 4·5 V flashlamp battery on your tongue. What do you feel?

Electrical fittings and appliances

Now and again, electrical fittings and appliances break or become loose and have to be repaired or replaced. These jobs should be done by an electrician or a grown-up who knows all about electricity. You must not interfere with fittings and appliances that are connected to the mains supply.

You must never push a drawing pin into an electricity cable. If you did, the point would pierce the insulation and touch the wires inside it. You can guess what would happen if someone touched the head of the pin.

Earthing

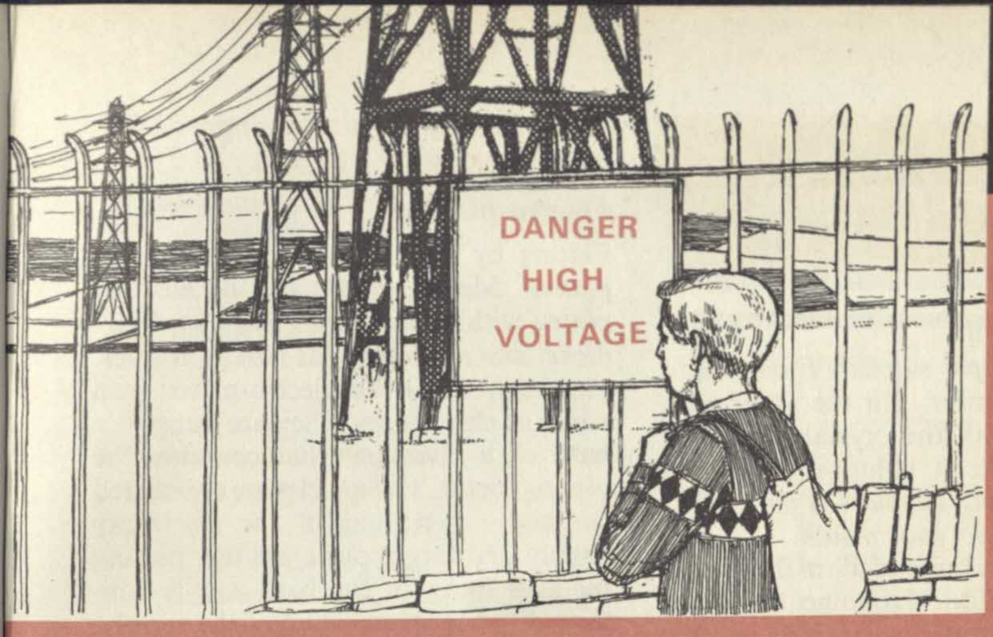
The large pin in the plug of an appliance is called the *earth pin*. It fits into the *earth socket* on a plug-point and, in this way, connects the earth to a wire from the metal frame of the appliance.

Earthing prevents electric shocks and damage to fittings and appliances. If a live wire should come loose and touch the frame, the current flows to the earth and no damage is done. If a live wire touches a frame that is not earthed, the current flows to the earth through *your body* when you touch the appliance.

MORE THINGS TO DO

1. Write a few sentences about the dangers of using electricity.
2. Find out why a bird can perch quite safely on an overhead electricity cable.

Danger! Electricity!

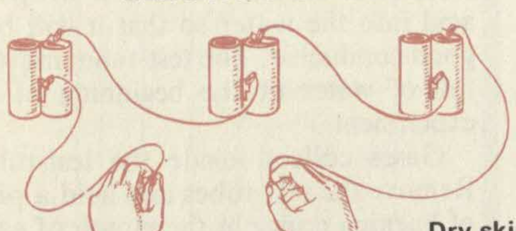


BATHROOM SAFETY SWITCH

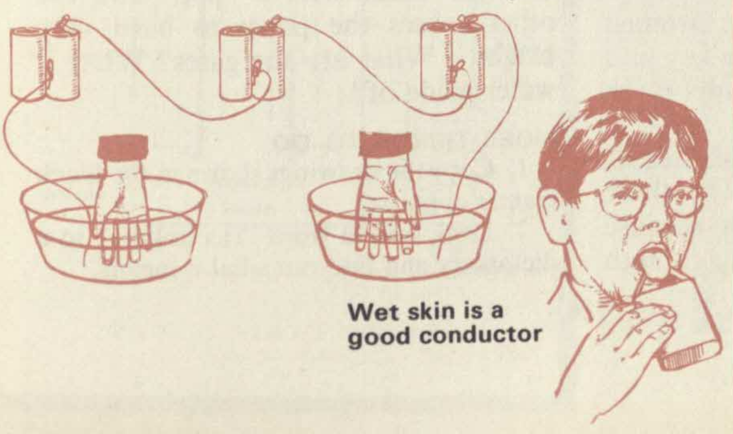
WATER IS A GOOD CONDUCTOR

Do not use electrical appliances in the bathroom

ELECTRIC SHOCKS



Dry skin is a poor conductor

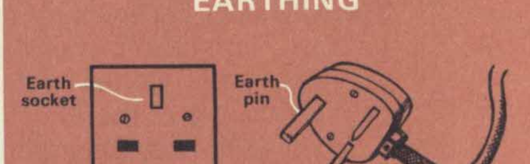


Wet skin is a good conductor

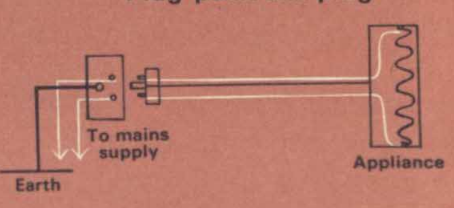
DANGEROUS PINS

Do not push a drawing pin into an electricity cable

EARTHING



Plug-point and plug



9 Electro-plating

Copper-plating

Drop some *copper sulphate crystals* into a cup of hot water. Stir the water with a pencil until all the crystals have dissolved to make a solution of copper sulphate. *Copper sulphate is poisonous; do not put it into your mouth.*

Place a clean knife blade in the copper sulphate solution. Examine the blade after a few minutes. It has become *copper-plated.* The iron in the surface of the blade has been exchanged for some of the copper in the solution.

Now, in the same way, copper-plate other articles made of iron or steel.

Copper-plating by electricity

Put 50 grammes of copper sulphate crystals in an earthenware jar. Pour about half a litre of boiling water from a kettle into the jar. Stir the water until all the copper sulphate crystals have dissolved. Put a few drops of *dilute sulphuric acid* into the copper sulphate solution.

Wrap two copper wires around a wooden rule. To one wire, attach a clean iron key; to the other wire, attach a piece of thick copper wire. Use paper clips to fasten the free ends of the wires to the terminals of a 6 V cycle battery. The wire from the key must be fastened to the – terminal. Lower the key and the copper wire into the jar. Support the ruler on the top of the jar.

Examine the key after 20 minutes. It has become copper-plated. The thick copper wire looks very clean because the copper in its surface has gone into the solution to replace the copper taken from the solution by the key.

Electro-plating

Plating by electricity is called *electroplating.* Metal articles can be electroplated with other metals, such as *silver, nickel* and *chromium,* as well as copper. Ornaments are often electro-plated with silver or chromium. They are hung in a bath of a chemical that contains the plating metal. The articles are connected to the – terminal of the electricity supply. A large piece of the plating metal is hung in the bath and is connected to the + terminal of the supply.

Electrolysis

In electro-plating, an electric current causes a chemical solution that contains a metal to "split" and give up the metal. But, an electric current will cause many chemicals, even those that do not contain metals, such as water and acids, to "split". This is called *electrolysis.*

The electrolysis of water

Use the equipment shown opposite to electrolyse water. Put a few drops of acid into the water so that it will be a good conductor. The test-tubes must be full of water at the beginning of the experiment.

Gases collect inside the test-tubes. Remove the test-tubes and hold a piece of burning paper in the mouth of each. One gas burns with a "pop" and the other causes the paper to burn very brightly. What are the gases? What is water made of?

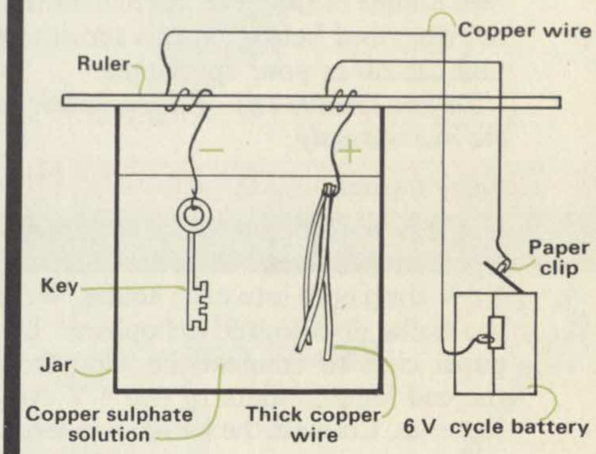
MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Look up the word "electrolysis" in a dictionary and find out what it means.

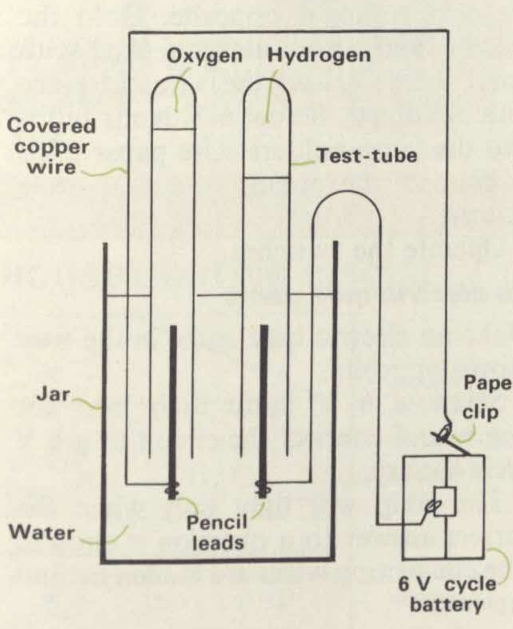
COPPER-PLATING

Electro-plating

COPPER-PLATING BY ELECTRICITY

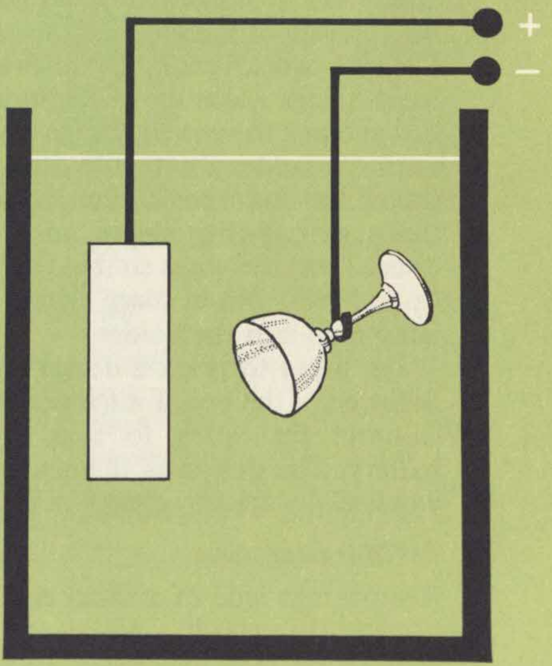


ELECTROLYSIS OF WATER



Water is made of hydrogen and oxygen

ELECTRO-PLATING



A layer of silver or chromium forms on the ornament

10 Some electrical models

Making electrical models

Make some of the electrical models that are described below. This is something you can do in your spare time.

Do not connect any of these models to the mains supply.

Fairy lights

Use covered copper wires to connect eight lamp-holders in series. Screw a 1·5 V lamp bulb into each holder. Wrap the bulbs in coloured cellophane. Use paper clips to connect the wires from the end lamp-holders to two 6 V cycle batteries. Connect the batteries in series.

What is the voltage on each lamp? What happens if any one of the lamp bulbs fails to work?

An illuminated sign

Use a nail to make two small holes in the top side of a small cardboard box. Connect two covered copper wires to a lamp-holder. Place the holder inside the box and pull the wires through the holes until the holder fits tightly against the top of the box. One of the pictures on the page opposite shows how this is done. Twist the wires so that the holder cannot move out of place. Screw a 6 V lamp bulb into the holder.

Use a pin to prick a design of holes in the lid of the box. Fit the lid in place. Connect the wires to a 6 V cycle battery. The design is illuminated and would show up very clearly in the dark.

An imitation fire

Remove one side of a small cardboard box. Fit a lamp-holder inside the box in the way shown opposite. Screw a 6 V lamp bulb into the holder. Dab a little black paint on red crepe paper. Cover the lamp with the paper. Connect the lamp to a 6 V cycle battery.

An electro-typer

For this model, you need the equipment for copper-plating by electricity described in Chapter 9.

Warm the end of a candle and allow the molten wax to drip on to a flat iron plate, about 8 cm long and 2 cm wide. When the wax has set hard, scratch your name on the plate with a needle.

Connect the iron plate to the — terminal of the battery and lower it into the copper sulphate solution.

After about 15 minutes, remove the iron plate, rinse it well and then warm it so as to melt off the wax. Your name will be written in copper on the plate.

A house lighting circuit

Use a black crayon to draw a section of a house on a large wooden board. Make the circuit shown opposite. Hold the switches and lamp-holders in place with small screws. Hold the wires in place with Sellotape. Screw 6 V lamp bulbs into the lamp-holders. Use paper clips to connect the circuit to a 6 V cycle battery.

Operate the switches.

An electric quiz game

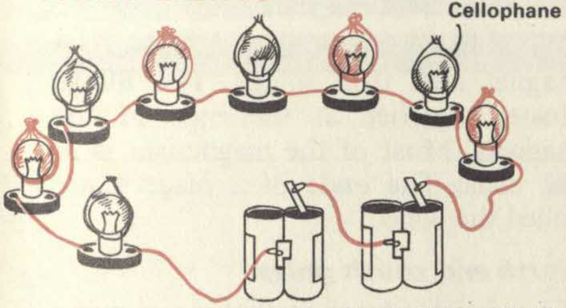
Make an electric quiz game in the way shown opposite.

Screw a 6 V lamp bulb into the holder and connect the circuit to a 6 V cycle battery.

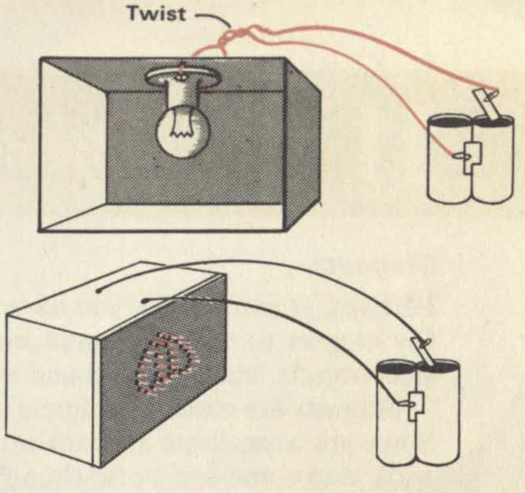
The lamp will light only when the correct answer to a question is chosen. The connecting wires are hidden behind the card.

Some electrical models

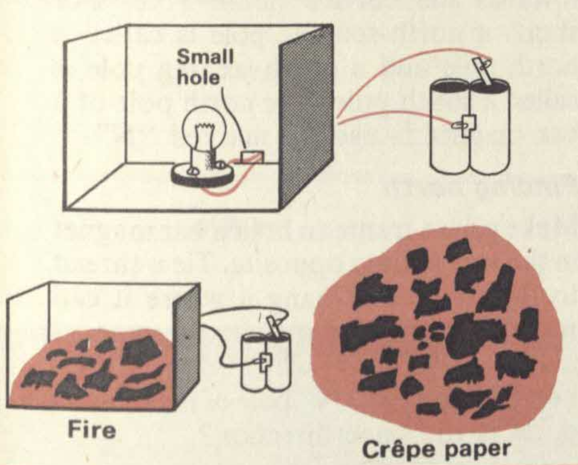
FAIRY LIGHTS



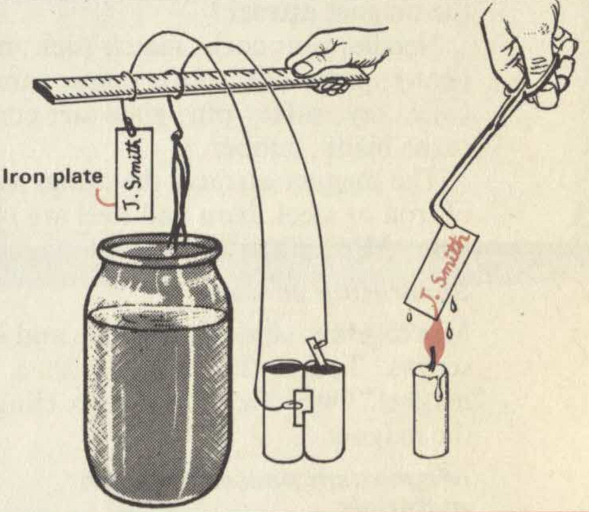
ILLUMINATED SIGN



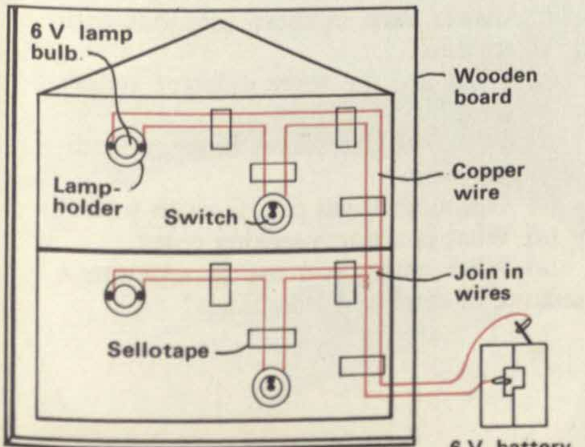
IMITATION FIRE



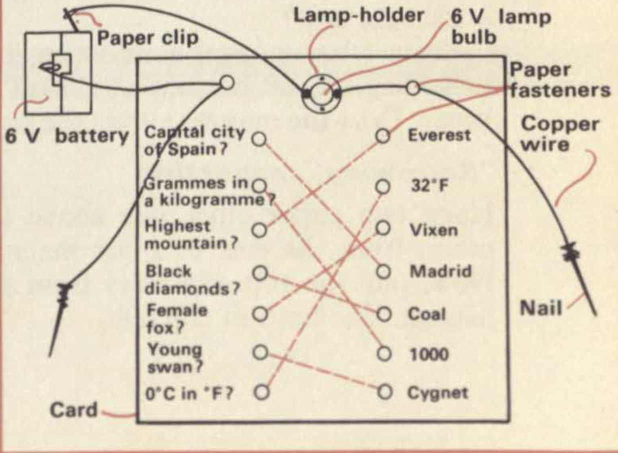
ELECTRO-TYPER



HOUSE LIGHTING CIRCUIT



ELECTRIC QUIZ GAME



11 Magnets

Magnets

Perhaps, at some time, you have used a toy *magnet* to pick up small iron and steel objects, such as nails and needles.

Magnets are made in different shapes. Some are bars, some are rods with ball-ends, and some are horse-shoe shaped.

Magnetic or not magnetic?

Bring the end of a bar magnet close to each of these things. Which things does the magnet attract?

Needle; pin; cork; match-stick; nail; penny; paper clip; brass screw; candle; coke, key; safety pin; glass jar; comb; razor blade; rubber.

The magnet attracts the things made of iron or steel. Iron and steel are *magnetic*. Most materials are not magnetic.

Separating screws

Mix together some small brass and iron screws. Touch the screws with a bar magnet. Only the iron screws cling to the magnet.

Magnetism passes through materials

Press a piece of cardboard flat against the end of a bar magnet and bring it close to an iron nail. Does the magnet attract the nail?

Bring a bar magnet close to an iron nail lying at the bottom of a dish of water. Does the magnet attract the nail?

"Borrowing" magnetism

Hang two paper clips, one above the other, from the end of a bar magnet. Now, pull the top clip away from the magnet. The bottom clip falls.

While the top clip is in contact with the magnet, it "borrows" some magnetism and attracts the bottom clip.

The poles of a magnet

Dip a bar magnet and a horseshoe magnet into iron filings. The filings cluster together at the ends of the magnets. Most of the magnetism is at the ends. The ends of a magnet are called the *poles*.

North and south poles

If a magnet is hung so that it can swing freely, one pole, which is called the *north-seeking pole,* will point towards the earth's *North Pole*; the other pole, called the *south-seeking pole,* will point towards the earth's *South Pole.* For short, a north-seeking pole is called a north pole and a south-seeking pole is called a south pole. The north pole of a bar magnet is usually marked "N".

Finding north

Make a wire frame to hold a bar magnet in the way shown opposite. Tie a thread to the frame and hang it where it can swing freely. After a time, the magnet becomes still. In which direction is north? Does the "N" pole of the magnet point in the same direction?

MORE THINGS TO DO

1. Make freehand drawings of the experiments **"The Poles of a Magnet"** and **"Finding North"**.

2. Answer each of these questions with a full sentence.

(*a*) What are the three different shapes of magnets?

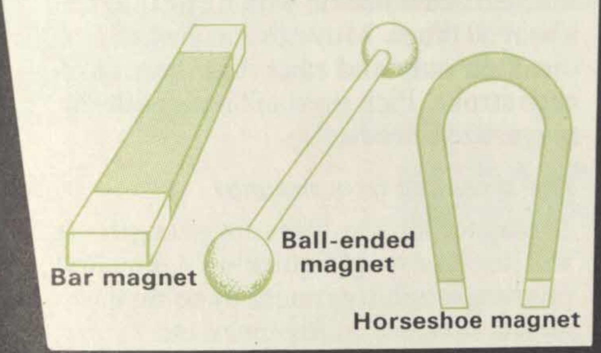
(*b*) Which of glass, steel, brass and rubber is magnetic?

(*c*) Can magnetism pass through water?

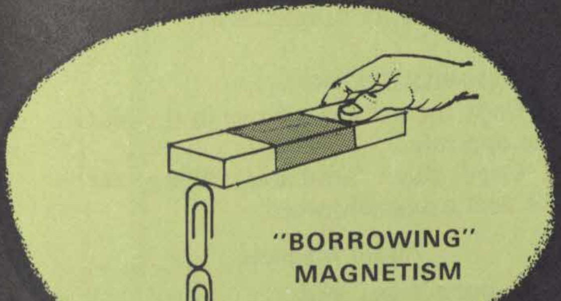
(*d*) What is a north-seeking pole?

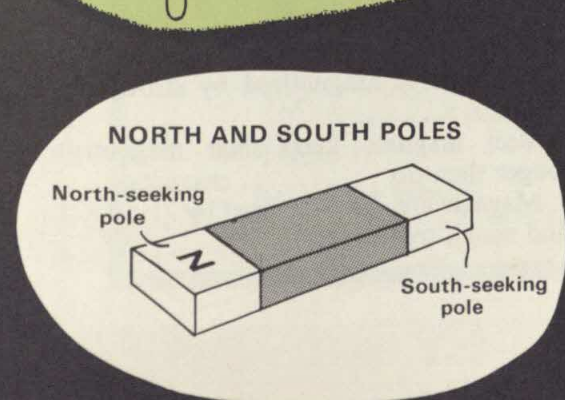
(*e*) What could you use to separate a mixture of sand and iron filings?

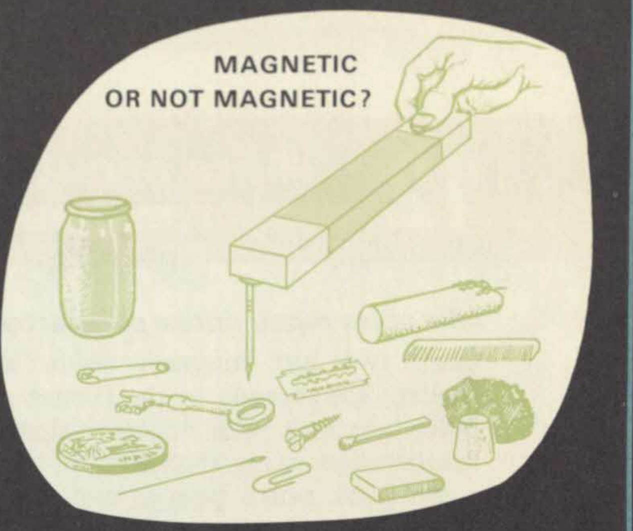
Magnets



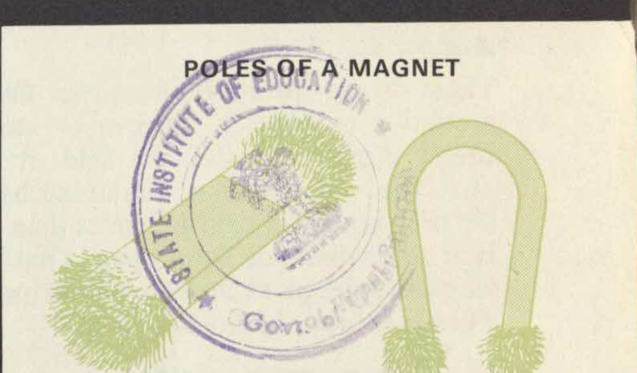
SEPARATING SCREWS


"BORROWING" MAGNETISM


NORTH AND SOUTH POLES


MAGNETIC OR NOT MAGNETIC?

MAGNETISM PASSES THROUGH MATERIALS


POLES OF A MAGNET

STATE INSTITUTE OF EDUCATION
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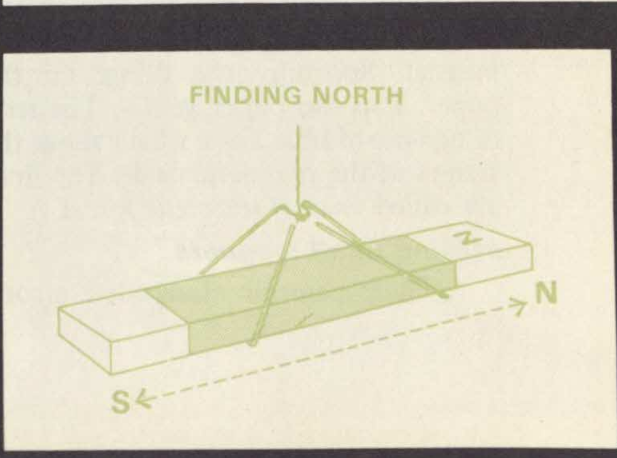

FINDING NORTH

12 More about magnets

Like poles repel; unlike poles attract

Place two bar magnets inside wire frames. Tie threads to the frames and hold them with your fingers so that the magnets can swing freely.

Bring the north pole of one magnet close to the south pole of the other magnet. They attract each other.

Now, bring the north pole of one magnet close to the north pole of the other. They repel each other. "Repel" means "push away". Bring the south poles close together. What happens?

A south pole repels a south pole and a north pole repels a north pole, but a north pole attracts a south pole. We can remember this by saying, *"like poles repel and unlike poles attract"*.

A magnetic field

There is an invisible *magnetic field* around a magnet. If an iron or steel object is placed inside the field, it is attracted by the magnet. The strength of the field is greater near the poles than it is at some distance from them. That is why a magnet picks up iron objects only when it is brought close to them.

Showing magnetic fields

Place a sheet of thick paper on top of a bar magnet and a horseshoe magnet. Sprinkle iron filings on the paper. Tap the paper gently. The iron filings move into lines which show the shapes of the magnetic fields. The lines are called *lines of magnetic force.*

Making small magnets

1. Place a needle alongside a strong bar magnet and leave it there for three days. At the end of this time, show that the needle has become a magnet by using it to pick up iron filings or very small iron nails.

2. Stroke a needle with a bar magnet about 50 times. Move the magnet in one direction only and raise it at the end of each stroke. Pick up small nails with the magnetized needle.

The strength of a magnet

A magnet slowly loses its strength. It will lose its strength quickly if it is heated or given rough treatment by being hammered, dropped many times, etc.

Most magnets are made of steel; a few are made of soft iron. Steel magnets keep their magnetism longer than do iron magnets, but it is easier to magnetize soft iron than steel.

Demagnetizing a magnet

Heat a magnetized needle in a bunsen burner flame until it is red-hot.

Let the needle cool down and then bring it close to some small iron nails. Does the needle attract the nails? Has the needle lost its magnetism?

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.

2. Copy these sentences, filling each space with a suitable word.

About Magnets

Like poles repel and .... poles attract.

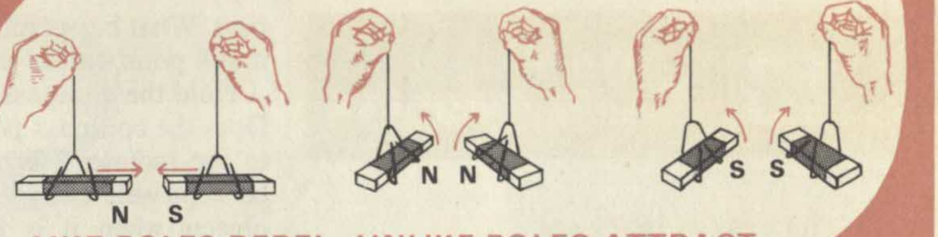
There is an invisible .... field around a magnet.

A needle is magnetized by stroking it with a ....

Steel magnets keep their magnetism longer than do .... magnets.

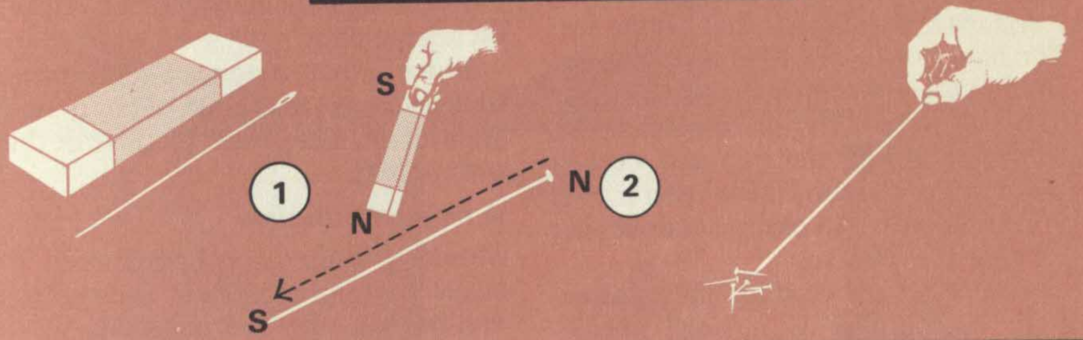
Magnets are demagnetized by .... and rough treatment.

More about magnets

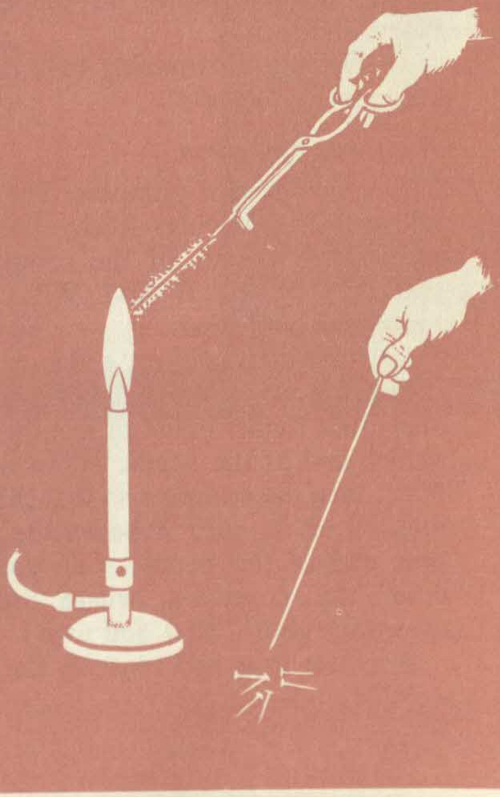


LIKE POLES REPEL; UNLIKE POLES ATTRACT

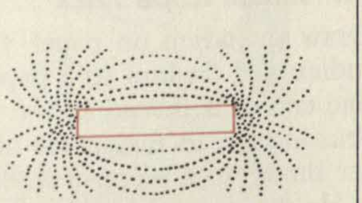
MAKING SMALL MAGNETS



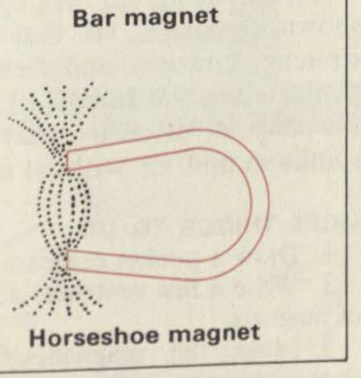
DEMAGNETIZING A MAGNET



MAGNETIC FIELDS



Bar magnet



Horseshoe magnet

13 Using magnets

The uses of magnets

Magnets have many uses. They are used in *compasses,* telephones, electric motors, radio sets, television sets and other electrical equipment.

During the Second World War, the Germans laid *magnetic mines* in the sea. The mines exploded when ships passed close to them. When a ship comes close to a magnetic mine, the magnet inside it tries to attract the iron and steel in the ship. As a result, the magnet moves and switches on an electric current that ignites an explosive.

Compasses are used for finding direction. A compass is a small needle-shaped magnet which is mounted so that it can swing freely. The north pole of the magnet points to the earth's North Pole.

A number of amusing toys can be made from magnets.

A pocket compass

Examine a pocket compass. The magnetized needle swings freely. The card inside the bottom of the compass is marked "N, S, E and W" – *north, south, east* and *west*.

Lay the compass on a flat wooden bench or table well away from radiators and other things made of iron or steel. Which end of the needle points north? Now, turn the compass so that the "N" marked on its card is below the north pole end of the needle. Can you tell, from the compass, where are the directions south, east and west?

Bring an iron nail close to the compass. What happens to the needle? Does it still point to the north?

Hold the compass near to a radiator. Does the compass point to the north or to the radiator? Why must a compass be kept well away from iron and steel objects when it is being used to find direction?

Magnetic dancers

Draw a few dancers on paper. Cut out the dancers and push large-headed nails through them. Stand the dancers on a large plate.

Move a bar magnet about on the underside of the plate. The dancers glide about. They seem to move of their own accord.

A magnetic mouse

Mould a lump of plasticine into the shape of a mouse. Push a large steel ball-bearing into the underside of the mouse. Place the mouse on a large plate.

Move a bar magnet about under the plate. The mouse "runs" about. Why?

An "Indian Rope Trick"

Draw an Indian on paper. Cut out the Indian and fix him to a paper clip. Tie one end of a thread to the clip. Use a drawing pin to fasten the other end of the thread to a piece of wood.

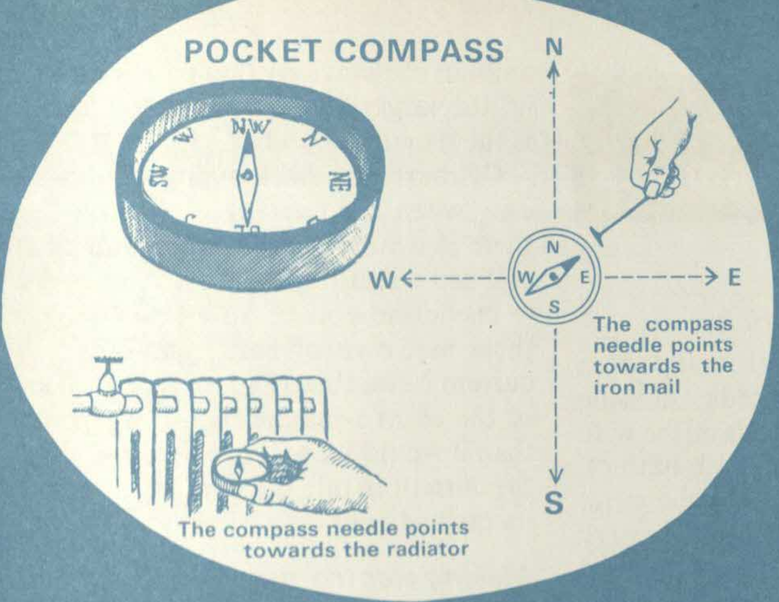
Hold a strong bar magnet, in the way shown opposite, so that the thread stretches upwards and there is a small gap between the Indian and the end of the magnet. It seems that the Indian stands in mid air without any support.

MORE THINGS TO DO

1. Draw a pocket compass.
2. Write a few sentences about the uses of magnets.
3. Make the magnetic fishing game shown opposite. You can do this at home.

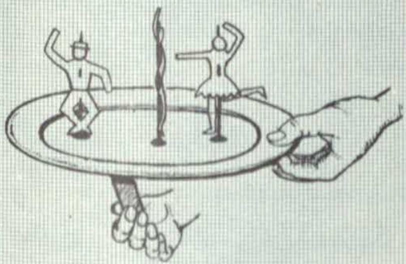
Using magnets

POCKET COMPASS



The compass needle points towards the iron nail

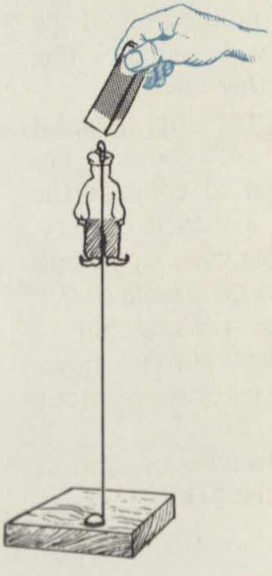
The compass needle points towards the radiator



Magnetic dancers

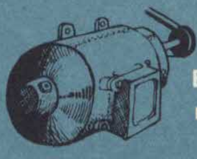
Magnetic mouse

"INDIAN ROPE TRICK"



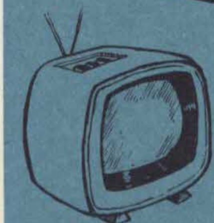
Compass

Telephone



Electric motor

Radio set

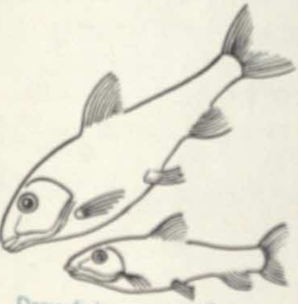


Television set

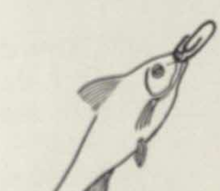
Mine

All these things contain magnets

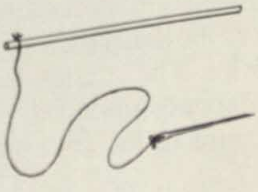
MAGNETIC FISHING GAME



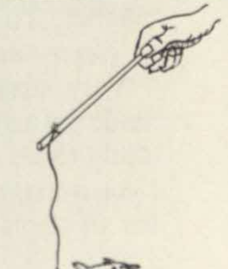
1. Draw fish on paper. Cut out the fish and colour them with crayons.



2. Fasten paper clips to the fish.



3. Tie one end of a thread to a magnetized needle. Tie the other end to a thin wooden rod.



4. Pick up the fish with the "fishing line"

14 Electro-magnets

Magnetism from electricity

Place a pocket compass on top of a copper wire so that the needle is in line with the wire. Hold the ends of the wire on the terminals of a 3 V torch battery. The needle turns away from the wire. Do *not* hold the wires on the battery too long or it will run down.

Do this again, but loop the wire around the compass. The needle turns farther away from the wire.

Now, wrap the wire around the compass several times. Hold the ends of the wire on the battery terminals. The needle turns even farther away.

Wind covered copper wire around a pencil to make a coil about 8 cm long. Use paper clips to connect the ends of the wire to a 6 V cycle battery. Bring a pocket compass close to the end of the coil. What does the needle do?

These four experiments show that:

1. When an electric current flows through a wire, it makes a magnetic field.
2. The greater the number of turns of wire, the stronger is the field.

Electro-magnets

When an electric current flows through a coil of wire, the coil becomes a magnet. This kind of magnet is called an *electro-magnet*.

Very strong electro-magnets can be made by using coils that contain very many turns of wire. The strength of an electro-magnet depends upon the number of turns of wire in its coil and the amount of electricity that passes through it; the larger the current, the stronger is the magnetic field.

Of course, an electro-magnet operates only when the current is on, and then there is a north pole at one end of its coil and a south pole at its other end.

Inside the coil of an electro-magnet, there is a *core* of soft iron. When the current is on, the core is magnetized and so the electro-magnet is much stronger than it would be without the core. When the current is off, the core loses most of its magnetism.

Making electro-magnets

1. Hold a large iron nail with tongs and heat it in a bunsen burner flame. When the nail is red-hot, remove it from the flame and let it cool down slowly. This softens the nail.

Wind thin covered copper wire around the nail to make a coil about 8 cm long. Fix the wire in place with Sellotape. Use paper clips to connect the ends of the wire to a 6 V cycle battery.

Pick up small nails with this electro-magnet.

Disconnect the battery. The nails are released.

2. Soften an iron nail and then bend it in a vice so that it is shaped like a horseshoe.

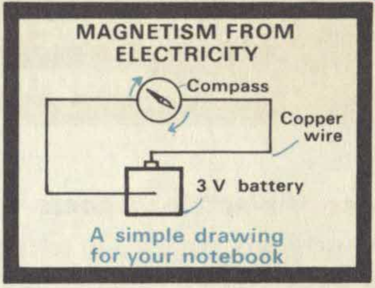
Wind thin covered copper wire on the arms of the horseshoe. Fix the wire in place with Sellotape. Connect the ends of the wire to a 6 V cycle battery.

Pick up small nails with this horseshoe electro-magnet.

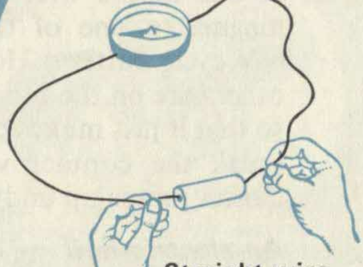
MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Write a short essay with the title *Electro-magnets*.

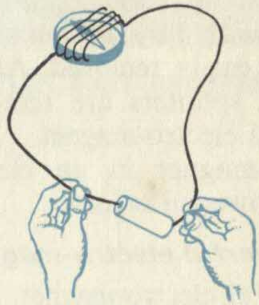
MAGNETISM FROM ELECTRICITY



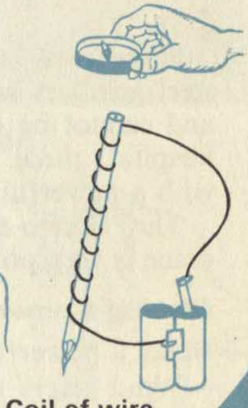
A simple drawing for your notebook



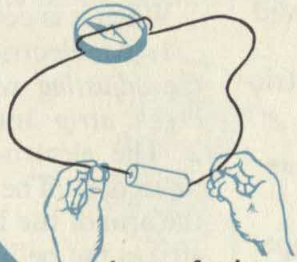
Straight wire



Several turns of wire

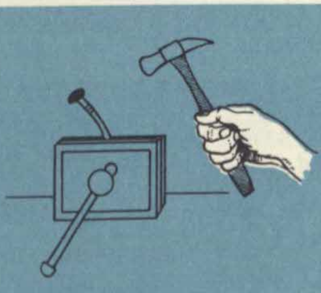


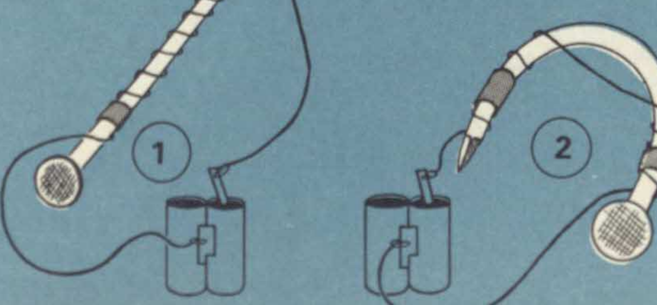
Coil of wire

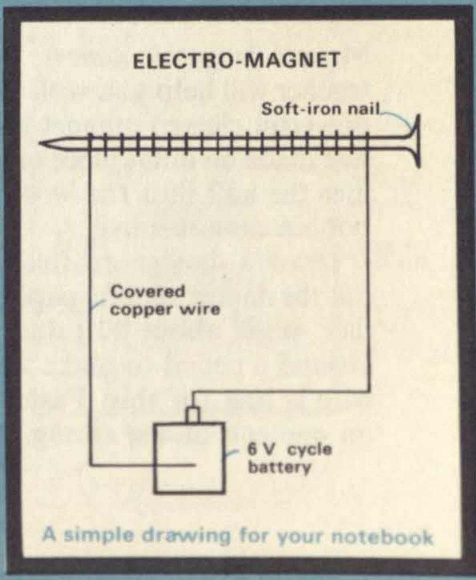


Loop of wire

MAKING ELECTRO-MAGNETS







A simple drawing for your notebook

15

Using electro-magnets

The uses of electro-magnets

Electro-magnets are used in telephones, *electric bells, electric cranes,* radio sets, television sets and other electrical equipment.

Sometimes, in an accident, iron or steel splinters stick in a person's eyes and cannot be easily removed. At the hospital, these splinters are removed with a powerful electro-magnet.

The electro-magnet in an electric crane is very powerful indeed.

Making a powerful electro-magnet

Make a powerful electro-magnet.

Wind layers of thin covered copper wire on to an empty cotton bobbin until the space between its ends is filled. Cover the wire with Sellotape. Soften a large flat-headed iron nail and push it through the hole in the bobbin. Use paper clips to connect the ends of the wire to a 6 V cycle battery.

Pick up iron nails with this electro-magnet. Notice that it is quite powerful.

A magnetic dancer

Make a *magnetic dancer*. Perhaps your teacher will help you with this. Place the powerful electro-magnet that you have just made on a flat piece of wood. Hammer the nail into the wood so that the bobbin cannot move.

Draw a dancer on thick paper. Cut out the dancer and fix paper clips on her feet. Wind about 20 turns of thin wire around a pencil to make a spring. Steel wire is best for this. Fasten the dancer on one end of the spring. Tie a thread on the other end. Hang the dancer above the electro-magnet so that her feet nearly touch it.

Use a paper clip to connect the end of one of the wires from the electro-magnet to one of the terminals of a 6 V cycle battery. Hold the end of the other wire on the other battery terminal so that it just makes contact. Make and break the contact very quickly. The dancer jumps up and down.

An electric bell

An electric bell is shown on the page opposite.

When it is connected to a battery:

1. An electric current flows through the *adjusting screw* and the *make-and-break strip* into the electro-magnets. 2. The electro-magnets become magnetized. 3. The electro-magnets attract the arm of the hammer. 4. The hammer strikes the bell. 5. The make-and-break strip moves away from the screw. 6. The strip breaks contact. 7. The electric current stops flowing. 8. The electro-magnets become demagnetized. 9. The electro-magnets no longer attract the arm. 10. The arm, which is springy, returns to its original position. 11. The electric current flows once more.

This happens over and over again and so the bell goes on ringing.

The adjusting screw is used to alter the sound of the bell.

Using an electric bell

Examine and operate an electric bell if one is available. Make sure that you connect the bell to a battery of the correct voltage.

MORE THINGS TO DO

1. Draw an electric bell. Label its parts.
2. Make a list of the things in which electro-magnets are used.

Using electro-magnets

Television set

Telephone

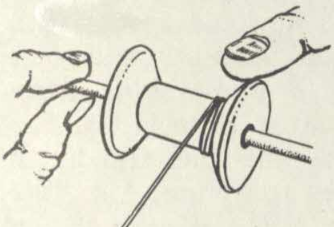
Electric bell

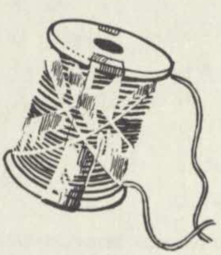
Electric crane

Radio set

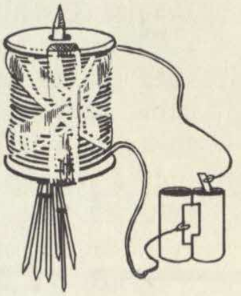
Hospital electro-magnet

MAKING A POWERFUL ELECTRO-MAGNET

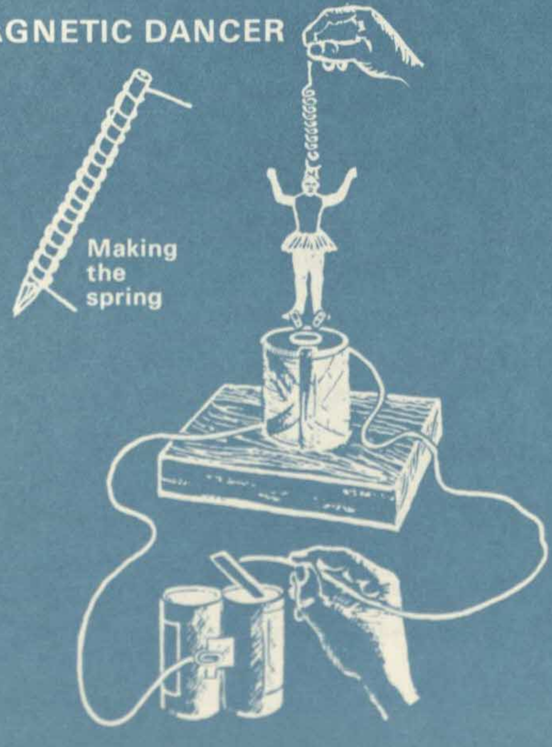

1. Wind wire on a bobbin.


2. Cover wire with Sellotape.

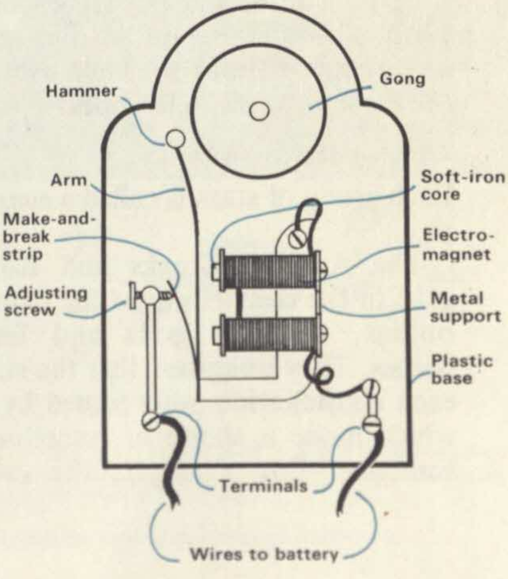
3. Soften a large nail.


4. Pick up iron nails.

MAGNETIC DANCER



ELECTRIC BELL



16 The sky at night

The stars

When you look upwards on a clear night, you see many tiny stars which seem to be scattered around the inside of a dark, bowl-shaped sky.

But, the stars are not tiny. They are very large balls of burning gases and are millions of kilometres across. For example, the distance across the star *Betelgeuse* is about 225 000 megametres.

The stars seem to be small because they are so far away, just as, in the same way, a large bird, which may be thirty centimetres or more across, will be only a tiny speck in the sky at a long distance. The nearest star to the earth is 40 million million kilometres away!

Sirius, the *Dog Star,* is not a large star but it is the brightest star in the sky because it is much nearer to the earth than are most of the other stars.

The stars are not near to each other, though they seem to be. They are many millions of kilometres apart. Also, they are not all at the same distance from the earth. Some stars are so distant that *astronomers* cannot see them even with the most powerful telescopes.

The constellations

Each group of stars is called a *constellation.*

The Ancient Greeks and Romans gave to the constellations the names of objects, animals, gods and famous heroes. They imagined that the stars in each constellation were joined by lines which made a shape of something or someone. For example, the crossed lines of the constellation *Cygnus* look like a swan. "Cygnus" means "The Swan".

Some of the better known constellations are shown on the page opposite.

The Milky Way

On a clear night, you can see a faint band of light stretching across the middle of the sky. This is the *Milky Way*. It contains many millions of stars which look faint because they are very distant.

A view of the northern sky

At the top of the opposite page, the sky is shown as it would appear to a person who is looking north on a clear night at about 8 p.m. during early November in Great Britain. For the sake of clearness, the stars are shown bolder than they really are. Also, the position of the *Milky Way* is shown with a thin white line. The *Pole Star* is marked with a cross and the two end stars of the *Plough* with an arrow. Can you recognize any of the constellations?

Looking at the stars

Look at the sky on a clear night in the country away from the glare of city lights. See if you can pick out some of the constellations. Find the Pole Star.

Look at the stars through a telescope if one is available. You will see more of the Milky Way.

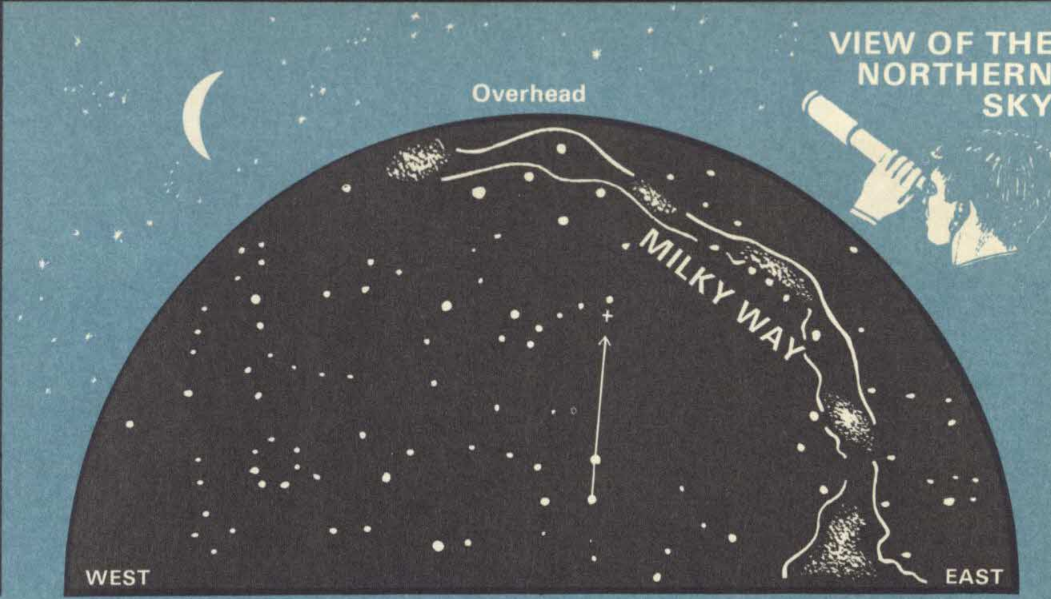
Making a constellation viewer

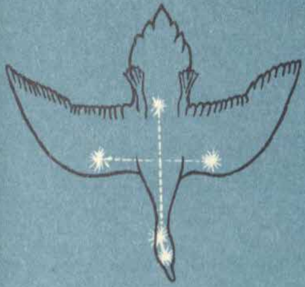
Make a *constellation viewer* in the way shown opposite.

MORE THINGS TO DO

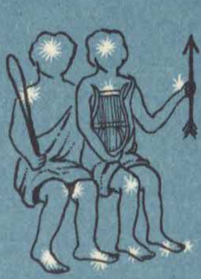
1. Draw *four* of the constellations. Print their names below them.
2. Look up the word "constellation" in a dictionary and find out what it means.

The sky at night

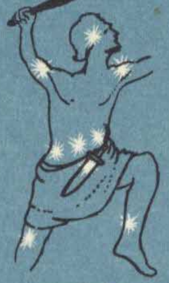




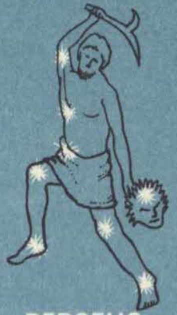
CYGNUS
The Swan



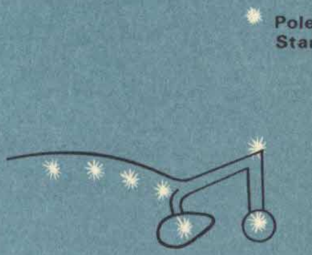
GEMINI
The Heavenly Twins



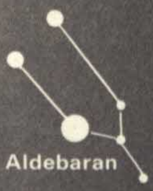
ORION
The Hunter



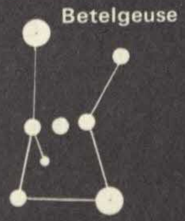
PERSEUS
The Son of Jupiter



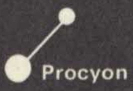
GREAT BEAR
The Plough, the Dipper, or Charles Wain



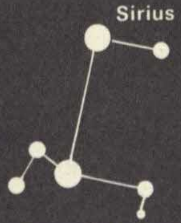
TAURUS
The Bull



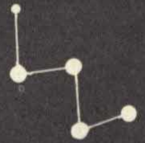
ORION
The Hunter



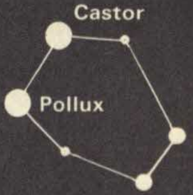
CANIS MINOR
The Little Dog



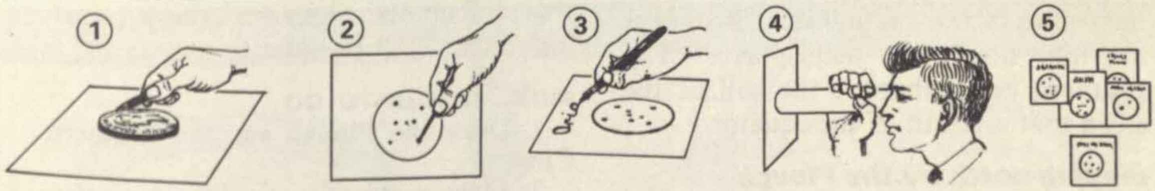
CANIS MAJOR
The Great Dog



CASSIOPEIA
"W"



GEMINI
The Heavenly Twins



MAKING A CONSTELLATION VIEWER

1. Draw a pencil line around a penny on a card which is about 8 cm square.
2. Use a needle to prick holes inside the circle to show the stars in a constellation.
3. Write the name of the constellation on the top of the card.
4. Hold the card up to the light and look at it through a cardboard tube from a toilet roll. The constellation appears to you as it would in the night sky.
5. Make cards for some of the other constellations.

17 Finding the way

Navigation

Ships' officers and air pilots have to know all about *navigation*. Navigation is the science of "finding the way".

A compass is used for finding the way. A compass needle always points north and south. But, long ago, before the compass was invented, sailors and desert travellers navigated by the stars and the sun. They used the stars at night and the sun during the day.

Finding direction by the stars

In the *northern hemisphere*, the Plough is used for finding direction. The two end stars of this constellation, which are known as the *Pointers*, point towards the Pole Star, which is almost exactly above the earth's North Pole.

The Pole Star cannot be seen in the *southern hemisphere* and so, in the southern hemisphere, the *Southern Cross* is used for finding direction. This constellation has the shape of a cross. An imaginary line joining *Crux*, the top star, to *Acrux*, the bottom star, points towards the earth's South Pole.

The northern hemisphere is the half of the earth that is north of the *equator*. The equator is an imaginary line around the centre of the earth. Great Britain is in the northern hemisphere. The southern hemisphere is the half of the earth that is south of the equator.

Finding north by the Plough

On a clear night, look for the Plough. When you have found it, imagine that there is a long line joining the Pointers. Can you see the Pole Star? In which direction is north?

Finding direction by the sun

Here are three ways for finding direction by the sun. Of course, you can only use these when the sun is shining.

1. Fairly early in the morning, when the sun is low in the sky, stand with your back towards the sun. You are facing west. The sun rises in the east and sets in the west.

Then, in the evening, stand with your back towards the sun. In which direction are you facing?

2. On a sunny day, at midday, which is 1 p.m., British Time, stand outside. Your shadow points north.

3. Hold a watch flat. Point its hour hand at the sun. Imagine that there is a line midway between the hour hand and the figure 1. This line points towards the south. Where is north?

A floating compass

Magnetize a needle by stroking it with a bar magnet. Push the needle through a cork. Float the cork on water in a plastic dish. You must not use an iron or steel dish. Why?

After a time, the cork becomes still and the needle points north and south.

Making a compass

Make a compass in the way shown opposite.

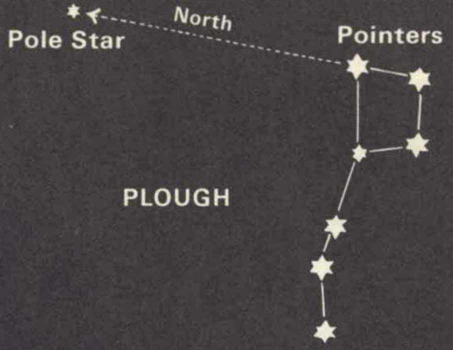
Remember that a razor blade is very sharp. Rub its edges on emery paper and then it will be safer to use.

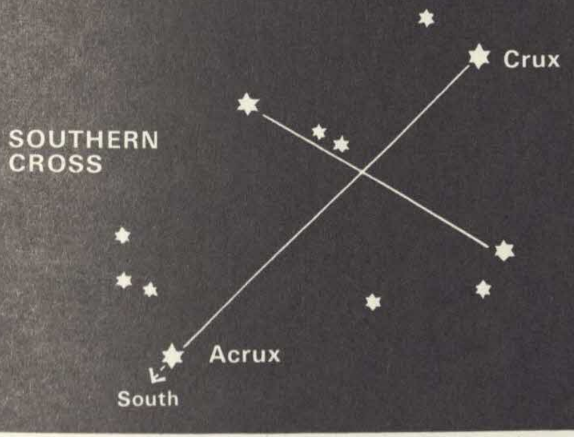
MORE THINGS TO DO

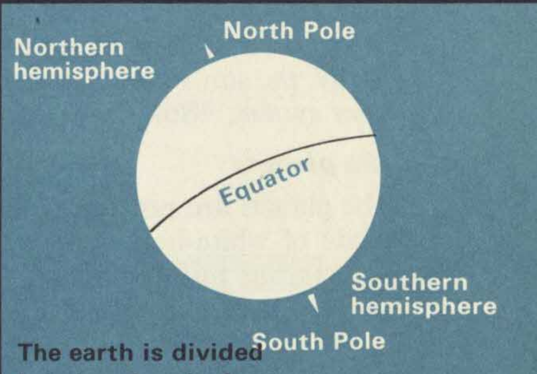
1. Draw the Plough and the Southern Cross.
2. Make a drawing to show how you could use a watch to find direction.
3. Write a few sentences about navigation.

Finding the way

Arabs finding their way by the stars

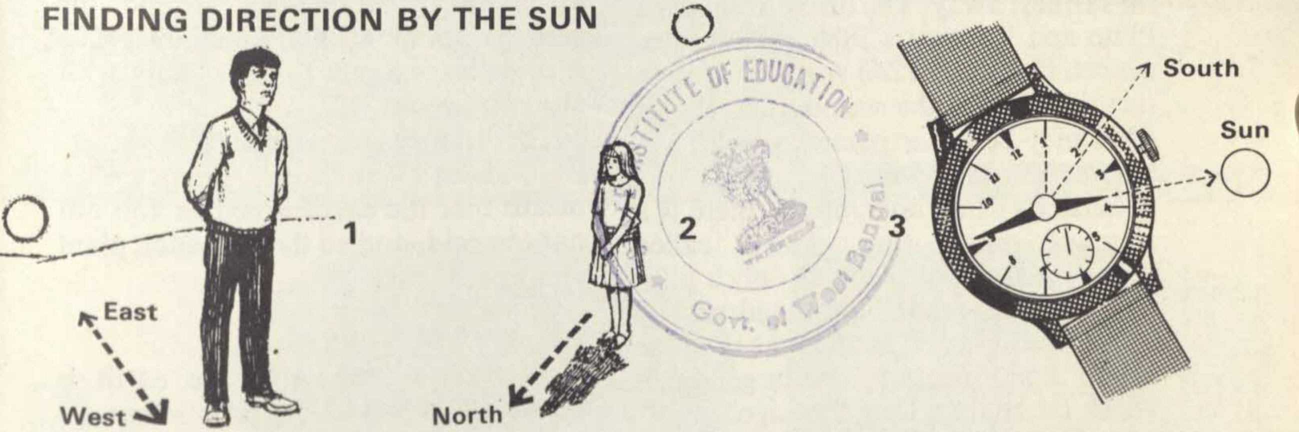






The earth is divided into two hemispheres

FINDING DIRECTION BY THE SUN



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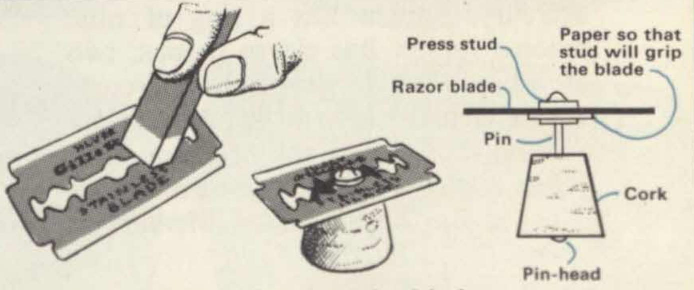
FLOATING COMPASS

The needle points north and south

MAKING A COMPASS



1. Magnetize a razor blade
2. Support the blade on a pin in a cork

Side view

18 The earth's family

The solar system

The earth belongs to a family of *planets* which travel around the sun in oval-shaped paths called *orbits*. The earth's family, or, perhaps, it would be better to say, the sun's family, is known as the *solar system*. "Solar" means "sun".

The planets

The planets are not stars. They are not made of white-hot burning gases. The planets are not luminous; they shine because they reflect light from the sun.

There are nine planets – *Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune* and *Pluto*. Mercury is the nearest planet to the sun. Pluto is the farthest away. The distance between Pluto and the sun is 5880 million kilometres. Pluto takes 248 years to travel in its orbit around the sun. Beyond Pluto, there may be other planets which have not yet been discovered.

Between Mars and Jupiter, there is a ring of many tiny planets called *asteroids*. Some of them are only a kilometre wide; others are hundreds of kilometres wide. It is thought that the asteroids are pieces from a large planet which broke up a long time ago.

The largest planets are Jupiter and Saturn. The smallest are Mars and Mercury. Saturn has a ring of nine moons. Jupiter has eleven moons, two of which are larger than Mercury. When Venus is seen in the east before sunrise, it is called the *Morning Star*. When it is in the west in the evening, it is called the *Evening Star*. Mercury is also called the Evening Star. Of course, neither Venus nor Mercury is a star.

Life on the other planets

There may be some simple plants on Mars because its atmosphere contains a little oxygen and there are no extremes of temperature. But, there cannot be life on the other planets as we know it on the earth. They are either too hot or too cold. Also, some have little or no atmosphere.

"Mother Earth"

Sometimes, the earth is called "Mother Earth". This is a good name because the earth, like a mother, gives us all the things we need – water to drink, plants and animals for food, and rocks and metals for making things.

The earth is shaped like a ball. The other planets are ball-shaped too. The distance across the earth is about 13 000 kilometres. The distance around the earth is about 40 000 kilometres. The earth takes one year to travel in its orbit around the sun.

The distance between the earth and the sun is about 150 million kilometres. This means that the earth is neither too hot nor too cold, and so there is much plant and animal life.

The earth is round

How do we know that the earth is round like a ball? Four proofs that the earth is round are shown opposite.

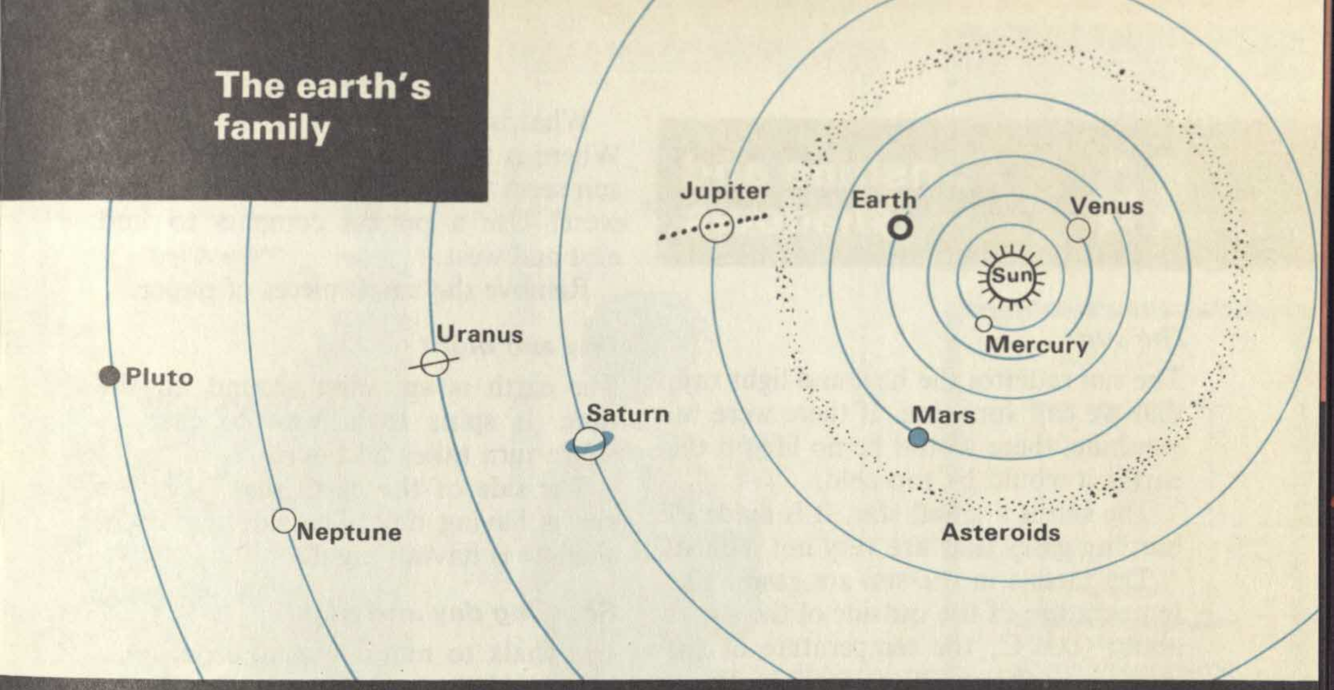
MORE THINGS TO DO

1. Make a list of the planets.
2. Write one sentence about each of these things.

Solar system; Pluto; asteroid; Morning Star; orbit.

3. Use an encyclopedia to find out what you can about *meteors* and *meteorites*.

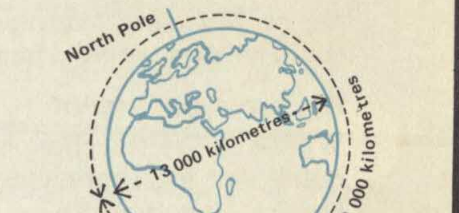
The earth's family



LIFE ON MARS

There may be plant life of a simple kind on Mars

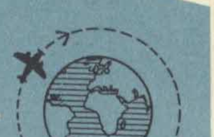
THE EARTH'S SHAPE AND SIZE

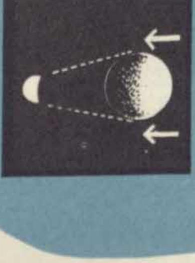


THE EARTH IS ROUND

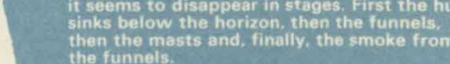
1. Aerial photographs taken at great heights show that the earth's surface is curved.

2. If an aeroplane continues to fly in the same direction, it will come back to the place from which it started.





3. When the earth comes between the moon and the sun, it casts a curved shadow on the moon.



4. When a ship is sailing away from the coast, it seems to disappear in stages. First the hull sinks below the horizon, then the funnels, then the masts and, finally, the smoke from the funnels.

19 Sunshine and shadows

The sun

The sun radiates the heat and light rays that we call sunshine. If there were no sunshine, there would be no life on the earth; it would be too cold.

The sun is a small star. It is made of burning gases that are very hot indeed.

The metals in the sun are gases. The temperature of the outside of the sun is about 6000°C; the temperature of the inside is about 20 000 000°C. What temperatures!

By the way, *you must never look at the sun through a telescope*. If you did, the fierce rays would damage your eyes.

The sun's movement

When you are travelling in a train, you notice that the countryside seems to be moving. But, you know that it is the train, and not the countryside, that is really moving. In the same way, during the day, the sun seems to move across the sky from east to west. But, really, it is the earth that is turning from west to east.

It is *noon* when the sun is at its highest point in the sky. Six hours before noon, the sun is in the east; six hours after noon, the sun is in the west.

Watching the sun's path

At 7 o'clock (British Time) in the morning, stand in front of a window that is facing south. Press a small piece of moist paper on the window to mark the position of the sun.

Do this every hour until 7 o'clock in the evening.

What is the shape of the sun's path? Where is the sun at midday? Does the sun seem to move from the east to the west? Use a pocket compass to find east and west.

Remove the small pieces of paper.

Day and night

The earth is spinning around all the time. It spins from west to east. A single turn takes 24 hours.

The side of the earth that faces the sun is having day. The side that is in shadow is having night.

Showing day and night

Use chalk to mark a small cross on a ball. Hold the ball near to a candle.

Suppose that the candle is the sun, the ball is the earth and the cross is a place on the earth's surface.

Turn the ball slowly to show how the place has night and day. Where is the cross at midday? Where is it at midnight? Where is it at dawn?

Eclipses

Now and again, the earth moves between the moon and the sun. The moon cannot be seen because it is in the earth's shadow. This is called an *eclipse* of the moon.

An eclipse of the sun happens when the moon comes between the earth and the sun.

Showing an eclipse of the moon

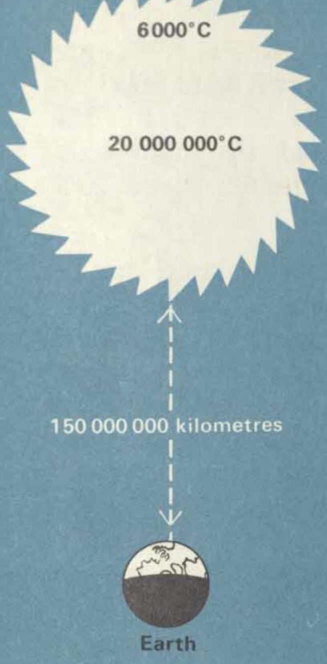
Hold a ball between a candle and a marble. Suppose that the ball is the earth, the marble is the moon and the candle is the sun. Is the moon eclipsed?

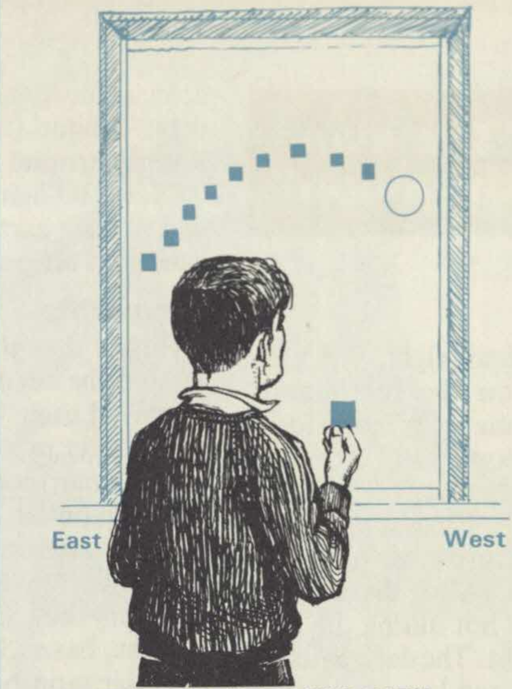
MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Write a few sentences about the sun.

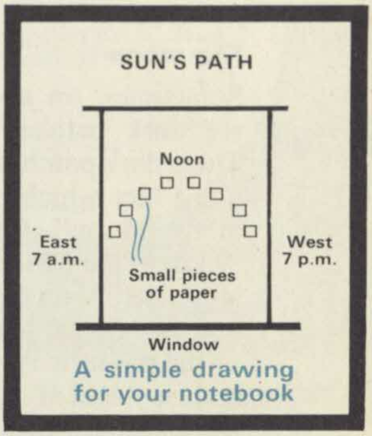
Sunshine and shadows

THE SUN IS A SMALL STAR

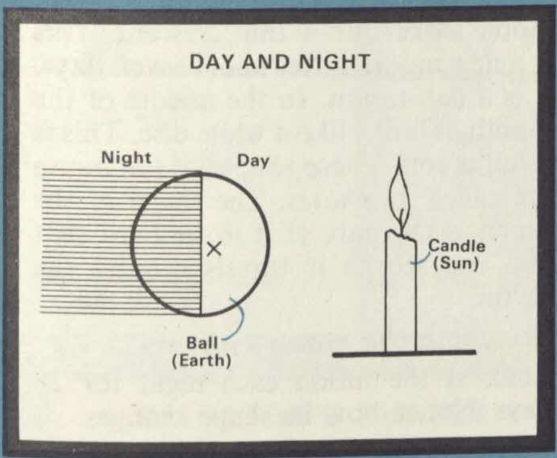




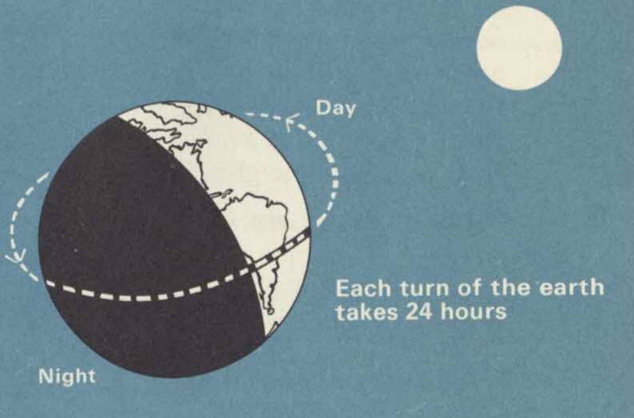
WATCHING THE SUN'S PATH



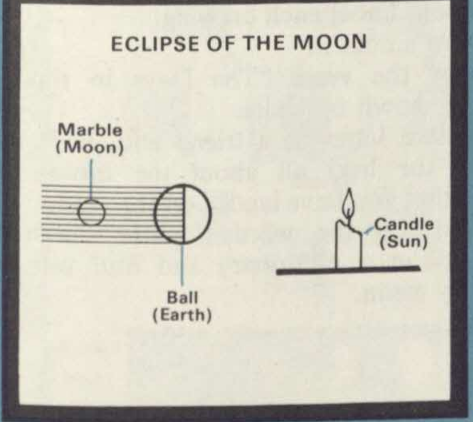
A simple drawing for your notebook



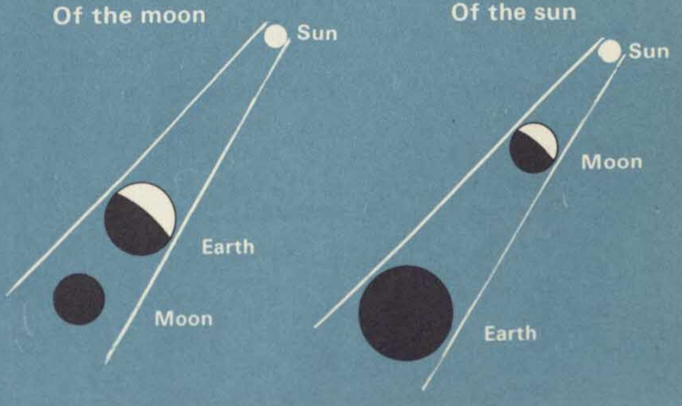
DAY AND NIGHT



Each turn of the earth takes 24 hours



ECLIPSES



20

"The man in the moon"

The moon

Sometimes, on a clear night, you can see dark patches on the full moon. These dark patches make the moon look like a face which people call "the Man in the Moon". Of course, there is no "Man in the Moon". There is no life at all on the moon because it has no water and no atmosphere. Also, the surface of the moon is very hot during the day and very cold at night. The dark patches are volcanic *craters* and large valleys of dust. They were once thought to be seas and oceans and were given romantic names, such as the Ocean of Storms, the Sea of Nectar, etc.

The moon is solid and round. It is made visible to us by the sunlight that is reflected by its surface. The moon is 400 000 kilometres away from the earth. It is our nearest neighbour in space.

Looking at the moon

On a clear night, look at a full moon through a telescope. Can you see the "seas and oceans"?

Travellers to the moon

In 1959, a Russian rocket, called *Lunik* 3, was sent on a journey around the moon. The far side of the moon was photographed for the first time.

In 1969, astronauts from the United States of America landed on the moon. They found it to be a dry and dreary place.

The moon's movement

Just as the earth moves in an orbit around the sun, the moon moves in an orbit around the earth. The moon's journey around the earth takes 28 days.

Now and again, the moon comes between the earth and the sun. This causes an eclipse of the sun.

The months

The time that the moon takes to travel around the earth once is called a *lunar month*. "Lunar" means "moon". There are 28 days in a lunar month and there are 13 lunar months in a year.

The months that we use are called *calendar months*. April, June, September and November have 30 days, February has 28 days and the other months have 31 days. There are 12 calendar months in a year.

The phases of the moon

At the beginning of a lunar month, the moon looks like a thin crescent. This is a new moon. After about seven days, it is a half-moon. In the middle of the month, it looks like a white disc. This is a full moon. These shapes of the moon are called its *phases*. The shape of the moon is the part of it in sunlight that you can see as it travels around the earth.

Watching the moon's phases

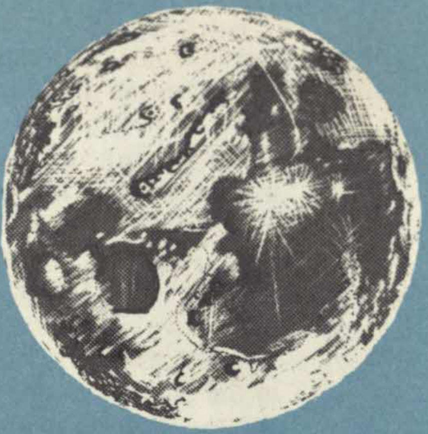
Look at the moon each night for 28 days. Notice how its shape changes.

MORE THINGS TO DO

1. Draw a new moon, a half-moon and a full moon. Label each drawing.
2. Draw Lunik 3.
3. Copy the verse "The Days in the Months" shown opposite.
4. Write a letter to a friend and, in it, tell him (or her) all about the moon. Imagine that you have landed on the moon.
5. Look up the words "crater" and "crescent" in a dictionary and find out what they mean.

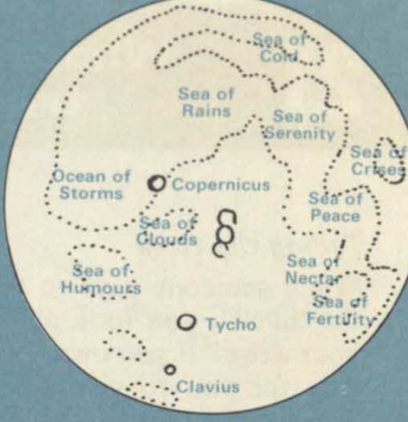
"The man in the moon"

THE FULL MOON



Notice the volcanic craters

MAP OF THE MOON

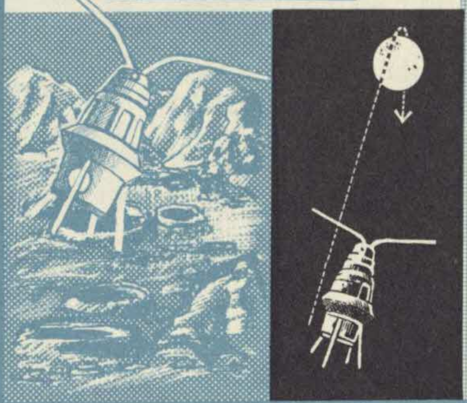


Copernicus, Tycho and Clavius are volcanic craters

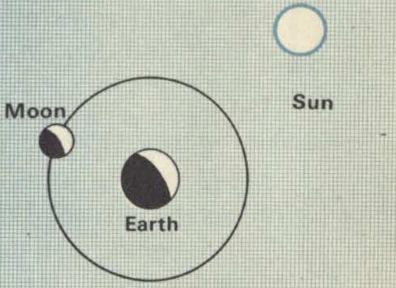
"THE MAN IN THE MOON"

The moon's surface looks like a face

LUNIK 3

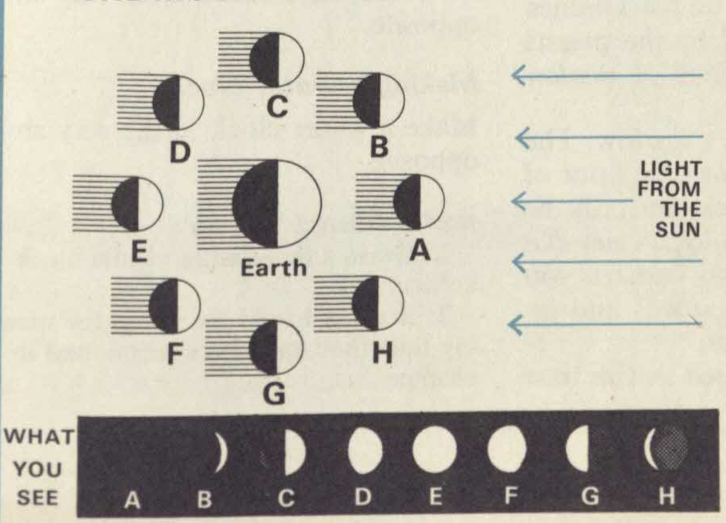


THE MOON'S MOVEMENT



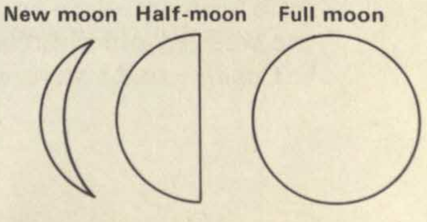
The moon takes 28 days to travel around the earth

THE MOON'S PHASES



The Days in the Months

Thirty days hath September,
April, June and November.
All the rest have thirty-one,
Excepting February alone,
Which has twenty-eight days clear,
And twenty-nine each leap year.



21 What's the time?

Telling the time

When someone says to you, "What's the time?", you look at the watch on your wrist – if you own a watch. It is so easy for you to give the time to the exact minute.

Long ago, before watches and clocks were invented, it was not so easy to tell the time. Men first measured the passage of time by the movements of the moon, earth and sun. The moon takes a month of 28 days to pass through its phases. The turning of the earth gives night and day. When the sun is low in the sky and in the east, it is morning. When it is nearly overhead, it is midday.

The tides can be used to measure time. The time between one high tide and the next high tide is about 12 hours.

A person can tell the time with his own shadow. His shadow is longest in the evening and early morning. He has little or no shadow at midday when the sun is nearly overhead.

Cleopatra's Needle, a stone monument which was brought to London from Egypt and erected on the Thames Embankment, was used by the priests of Ancient Egypt as a kind of *shadow clock*.

A shadow clock casts a shadow. The length of the shadow shows the hour of the day. A shadow clock can only be used when the sun is shining. A *sun-dial* is a kind of shadow clock. Perhaps you have seen sun-dials in gardens and on the walls of old churches.

Candle clocks were used in the time of King Alfred. A candle clock is simply a candle marked in equal sections. Each section burns away in one hour.

An *hour-glass* is two glass bulbs which are joined by a narrow neck. The bottom bulb is full of sand. When the hour-glass is turned upside down, the sand trickles from the top bulb into the bottom bulb. This takes one hour.

A *water clock* is a large jar of water. The water flows slowly from a tiny hole in the bottom of the jar. On the side of the jar, there are marks to show the time when the water has fallen to a certain level.

Making a simple sun-dial

Hammer a nail into a flat piece of wood. Place the wood in the sunshine so that one edge faces north. Every hour, use a pencil to mark the position and the length of the shadow. Keep a check on the time with a watch. Number each hour mark – 8, 9, 10, etc. Now, use your sun-dial for telling the time.

Using an egg-timer

Examine an *egg-timer*. Turn it upside down. Use a watch to find out how long the sand takes to trickle from the top bulb into the bottom bulb.

Making a candle clock

Make a candle clock in the way shown opposite.

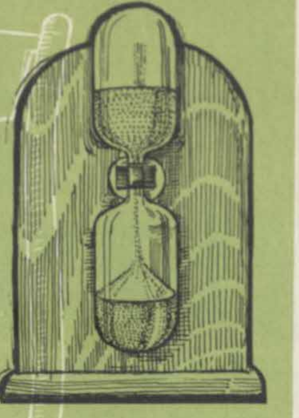
Making a water clock

Make a water clock in the way shown opposite.

MORE THINGS TO DO

1. Draw a sun-dial, a candle clock and an hour-glass.
2. Make a list of the things for measuring time that have been mentioned in this chapter.

EGG-TIMER



What's the time?

Watch

Alarm clock

Grandfather clock

Moon's phases

Hour-glass

Tides

Length of a shadow

Cleopatra's Needle

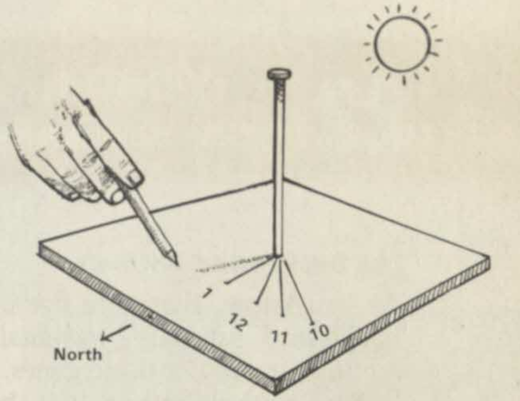
Shadow clock

Candle clock

Sun's movement

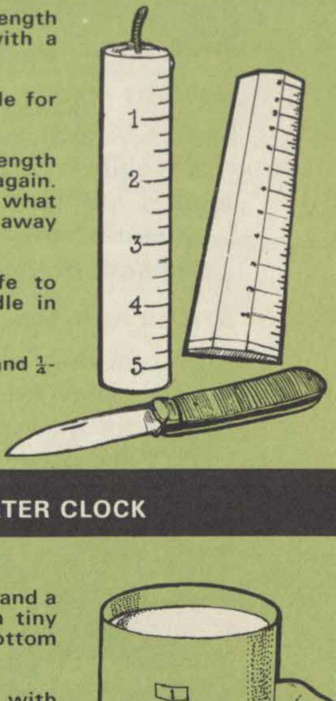
Water clock

MAKING A SIMPLE SUN-DIAL



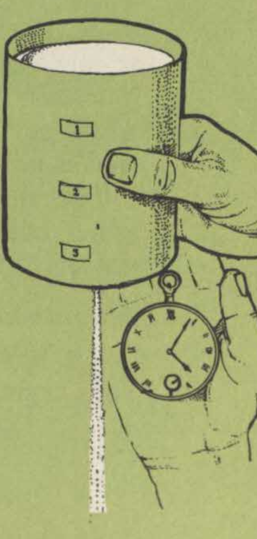
MAKING A CANDLE CLOCK

1. Measure the length of a candle with a ruler.
2. Burn the candle for 1 hour.
3. Measure the length of the candle again. Now you know what length burns away in 1 hour.
4. Use a penknife to mark the candle in hour-lengths.
5. Mark $\frac{1}{2}$-hours and $\frac{1}{4}$-hours.



MAKING A WATER CLOCK

1. Use a hammer and a nail to make a tiny hole in the bottom of a large can.
2. Fill the can with water.
3. Use a watch to find out how far the water falls in 1 minute.
4. Use bits of gummed paper to mark the can in minutes.



22 Cold-blooded animals

The backboned animals

As you know, there are five classes of backboned animals – *mammals, birds, reptiles, amphibians* and *fishes*.

The mammals and the birds are warm-blooded. The reptiles, amphibians and fishes are cold-blooded.

Which of these are cold-blooded?

Grass-snake; frog; whale; seal; penguin; turtle; tortoise; bat; eel; salmon; bison.

Reptiles

Snakes, lizards, tortoises, turtles, alligators and crocodiles are reptiles. Most reptiles are land animals, but some, such as the turtles and the crocodiles, spend most of their time in the water.

British reptiles

There are only six kinds of reptiles in Britain. They are the *grass-snake,* the *adder,* the *smooth snake,* the *common lizard,* the *sand lizard* and the *slow-worm.*

The commonest snake is the grass-snake. It is grey-green in colour and is quite harmless. The adder, or *viper*, as it is sometimes called, is poisonous. You can tell an adder by the black zigzag pattern along its back. Smooth snakes are very rare.

The slow-worm, or *blind-worm*, is about one foot long and looks like a very large worm. It is a legless lizard.

Amphibians

Frogs, newts and toads are amphibians. They begin their lives as *tadpoles,* which live in water, and then change into land animals. A newt looks like a lizard, but a newt is an amphibian and not a reptile.

British amphibians

There are seven kinds of amphibians in Britain. They are the *common newt,* the *great crested newt,* the *smooth newt,* the *common frog,* the *edible frog,* the *common toad* and the *natterjack toad.*

Fishes

Fishes, of course, are water animals. They have fins instead of legs. A fish has a streamlined body so that it can move through the water easily.

British freshwater fishes

There are many kinds of fish living in the lakes, rivers and canals of Great Britain. Some of these freshwater fishes are shown on the page opposite.

Making a vivarium

Make a *vivarium.* A vivarium is a home for animals.

Fill the bottom of an old plastic sink bowl with living turf and a few stones. Put a flat dish of water in the bowl so that it is level with the turf. Use a hammer and a nail to make a few small ventilation holes in the side of the bowl. Cover the bowl with a sheet of glass so that the animals cannot escape.

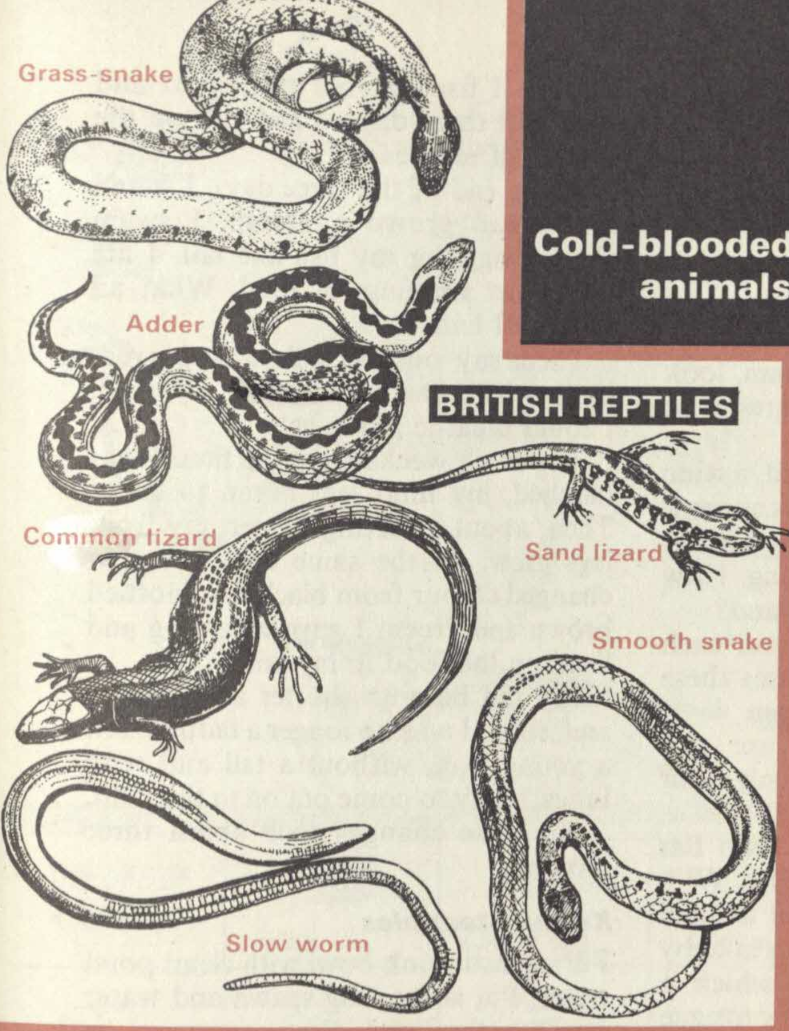
Keep lizards, newts, frogs and toads in this vivarium. Feed them on chopped earthworms, spiders, snails, slugs, grubs, insects, etc.

MORE THINGS TO DO

1. Use tracing paper to copy some of the drawings of cold-blooded animals shown opposite. Print their names below them.
2. Make a list of the British reptiles.
3. Make a list of the British amphibians.
4. Make a list of the British freshwater fishes shown opposite.

Cold-blooded animals

BRITISH REPTILES



BRITISH AMPHIBIANS

Edible frog

Natterjack toad

Common frog

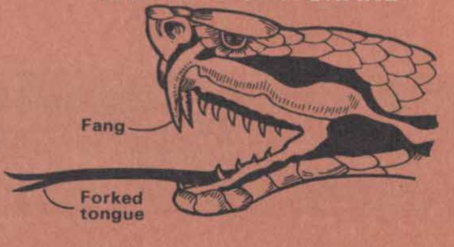
Common toad

Smooth newt

Great crested newt

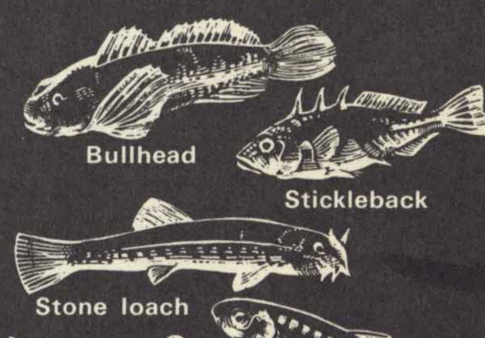
Common newt

THE HEAD OF A SNAKE

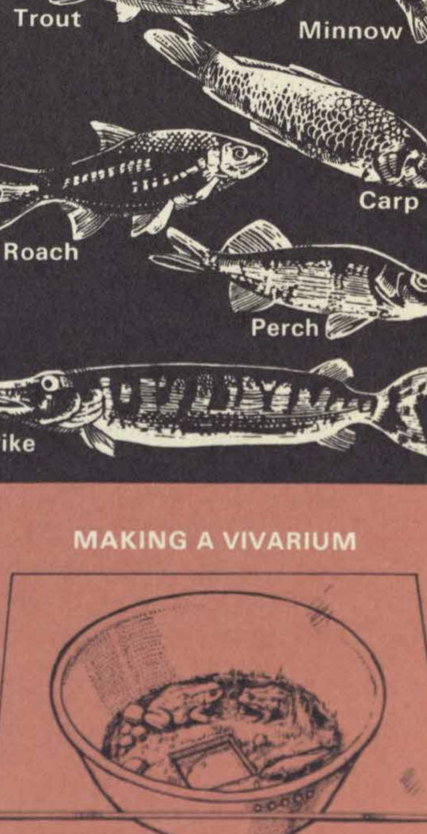


The *fangs*, which can pierce the skin of another animal, are long sharp teeth filled with poison and pointing backwards.

SOME BRITISH FRESH-WATER FISH



MAKING A VIVARIUM



23 The story of the frog

Looking at a frog

If there is a frog in your vivarium, look at it closely. If not, look at a preserved specimen.

Notice that it has a large head, a wide mouth and no neck. Its body is streamlined so that it can move through water easily. Its hind legs are very long. How does the frog move about on land?

The hind feet are webbed and each foot has five toes. The frog uses these webbed feet as paddles when it is swimming. The front feet are not webbed and each foot has only four toes.

The frog has two nostrils, two flat *ear-drums* and two very large eyes. With these large eyes, it can see all around without moving its head. It can take by surprise the flying insects on which it feeds. The frog has a long sticky tongue which it flicks out very quickly to catch an insect.

The frog's story

Let us pretend that the frog is able to speak. This is how he might tell the story of his life as a *tadpole.*

"I began my life as a single, small, black egg among a mass of other eggs, called *frog spawn.* Each egg was inside a ball of jelly to prevent the egg from being crushed or eaten by animals.

My egg grew and, very soon, I was shaped like a comma. I had a head and a short tail.

After a short time, I had become quite free of the jelly. I was a young tadpole. I fixed myself to a weed and rested for three days. I had gills on the outside of my head.

At the end of the three days, I found that I had grown a mouth. I swam about, wiggling my fish-like tail. I ate enormous amounts of food. What an appetite I had!

Then, my outside gills disappeared, but new gills had grown inside my head. I could breathe like a fish.

About six weeks from the time I was hatched, my hind legs began to grow. Then, about a fortnight later, my front legs grew. At the same time, my skin changed colour from black to a mottled brown and green. I gave up eating and lived on the food in my tail.

My tail became shorter and shorter and, soon, I was no longer a tadpole but a young frog, without a tail and with lungs, ready to come out on to the land.

All these changes took about three months."

Keeping tadpoles

Fill a plastic sink bowl with clean pond water. Put some frog spawn and water weeds in the bowl. Frog spawn can be found in March.

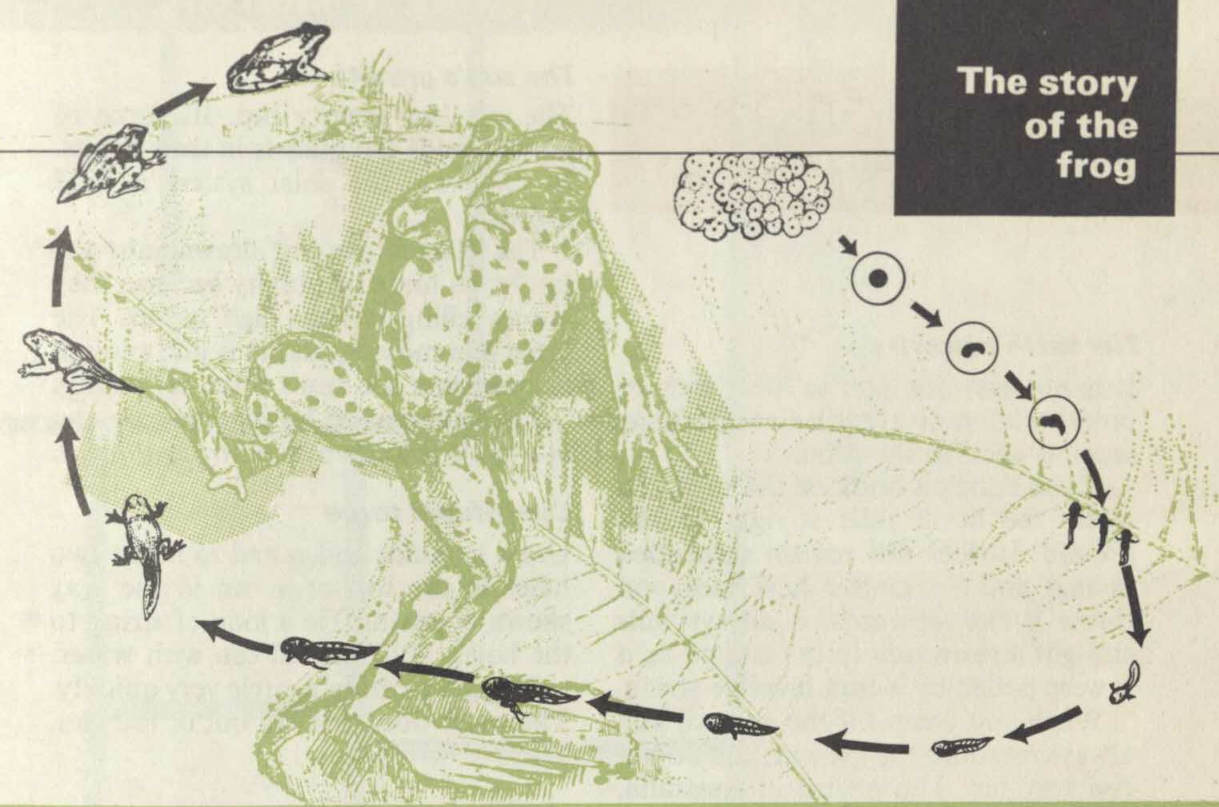
Watch the tadpoles hatch out and grow into young frogs.

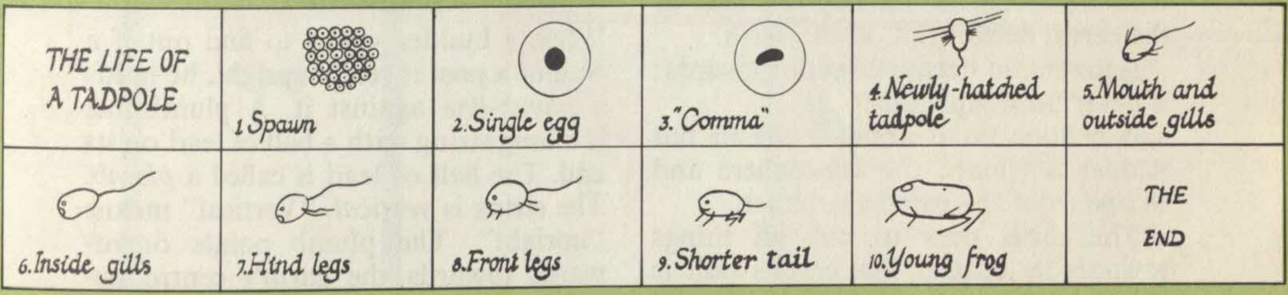
When the tadpoles have legs, place large stones in the bowl so that the young frogs will be able to climb out of the water.

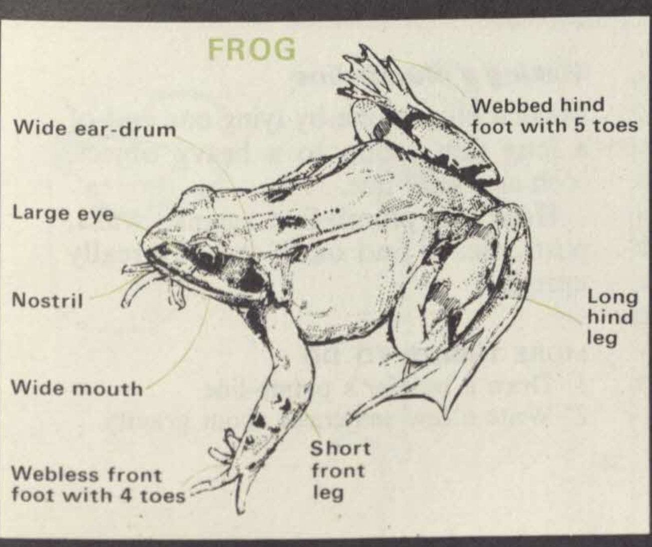
MORE THINGS TO DO

1. Draw a frog. Label its parts.
2. Copy the "comic strip" drawing shown opposite which shows the life of a tadpole.
3. Imagine that you are a frog. Write the story of your life as a tadpole.
4. Find out all you can about the spawn and tadpoles of toads and newts.

The story of the frog



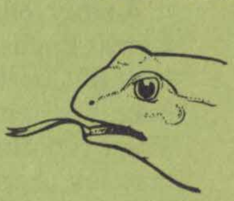




FROG'S EGG

Actual size

FROG'S TONGUE



KEEPING TADPOLES

24 The force of gravity

The earth's gravity

It is not easy for you to lift a sack of potatoes or pull a garden roller. They seem to stick to the ground.

If you knock a book off the edge of a table, the book falls straight to the ground; it does not remain suspended in mid air. No matter how hard you throw a ball upwards, it always falls straight downwards to the ground as if it were pulled by a thin invisible string.

When you jump off the ground, you always return to the ground; you do not rise very far. The people in Australia, who are living on the opposite side of the earth, do not fall off the earth.

A mountain stream flows downwards; it never flows upwards.

A balloon floats about in the air but it does not leave the atmosphere and escape from the earth altogether.

The earth tries to pull all things towards its centre. The earth's pull is called its *force of gravity*. A force is a *pull* or a *push*.

A story tells us that Sir Isaac Newton, a great English scientist who lived at the time of Charles I and Oliver Cromwell, once saw an apple fall from a tree. There is nothing special about that, you may say. Apples were falling from trees long before Newton was born. But, he thought about what he had seen. He decided that things are attracted to the earth by its gravity. But, no one really knows the cause of this mysterious force.

The sun's gravity

The sun has gravity too. Its force of gravity holds the planets in their orbits. In this way, the solar system is held together.

The planets are not drawn into the sun by its force of gravity because they are travelling at very high speeds. The force of a moving planet is just enough to overcome the sun's force of gravity.

The force caused by an object moving in a circle is known as *centrifugal force*.

Centrifugal force

Use a hammer and a nail to make two holes in the top of a can in the way shown opposite. Tie a loop of string to the holes. Half fill the can with water.

Swing the can in a circle very quickly. The water does not fall out of the can. Why?

A builder's plumb-line

When a builder wants to find out if a wall or a post is really upright, he holds a *plumb-line* against it. A plumb-line is a long string with a ball of lead on its end. The ball of lead is called a *plumb*. The string is *vertical*. "Vertical" means "upright". The plumb points downwards towards the earth's centre because it is attracted by the earth's gravity.

Making a plumb-line

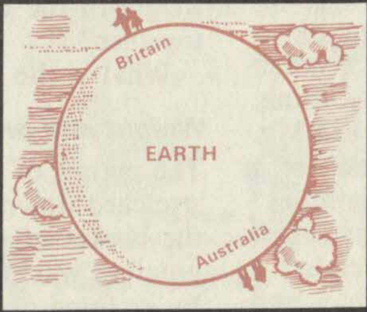
Make a plumb-line by tying one end of a long thin string to a heavy object, such as a steel nut.

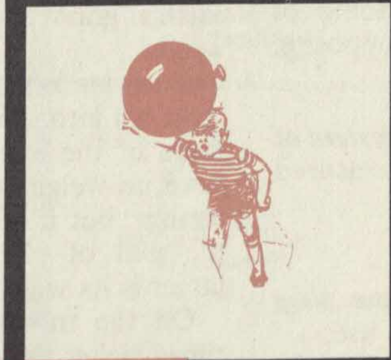
Hold the plumb-line against walls, posts, etc. to find out if they are really upright.

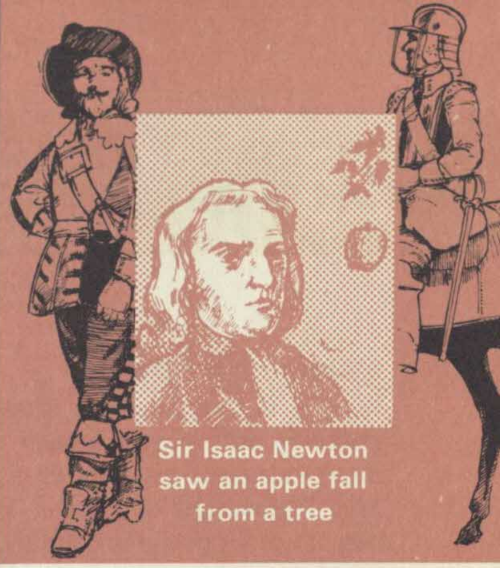
MORE THINGS TO DO

1. Draw a builder's plumb-line.
2. Write a few sentences about gravity.

The force of gravity

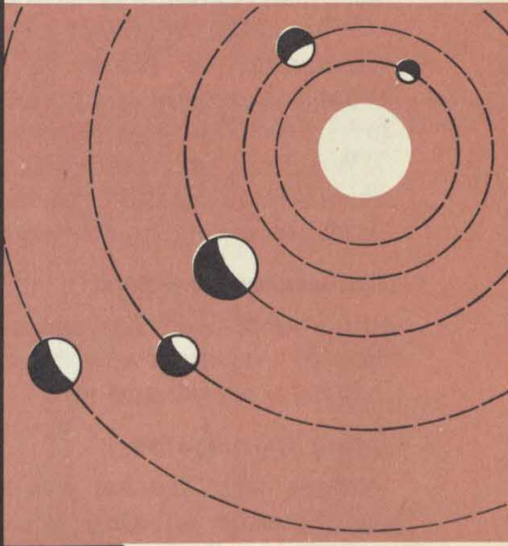




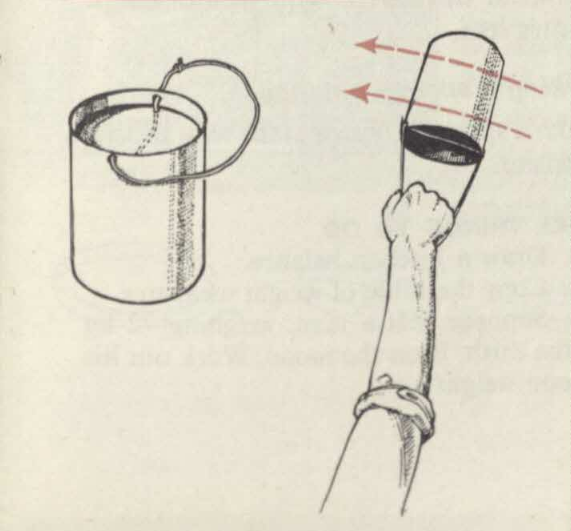


Sir Isaac Newton saw an apple fall from a tree

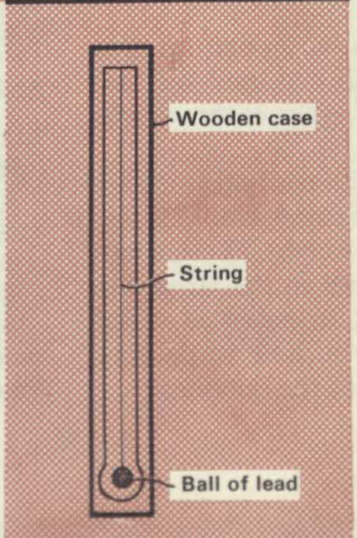
THE SUN'S GRAVITY



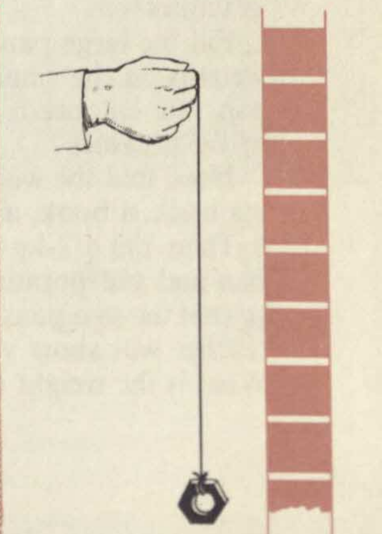
CENTRIFUGAL FORCE



BUILDER'S PLUMB-LINE



MAKING A PLUMB-LINE



25 Weight

Measuring weight

Weight is measured in *grammes, kilogrammes* and *megagrammes*. For short, these measures are written as *g, kg* and *Mg*. The weight of a small thing, like a bag of apples or a piece of fish, is given in kg and g. The weight of a large thing, like a load of coal, is given in kg and Mg.

What is the weight of a quarter of a kilogramme of butter in grammes? What is the weight of a person measured in? Do you know your own weight?

Weight is measured with *scales* and *balances* of different kinds. Some of these are shown on the page opposite.

The imperial system

Britain once used the *imperial system of measures*, in which weight was measured in *ounces, pounds* and *tons*.

Using shop scales

Perhaps your teacher has some *shop scales* that he will allow you to use.

Examine the scales. Look at the weights. Are they marked in kilogrammes?

Fill the large pan with potatoes. Put weights on the small pan until the two pans are balanced. What is the weight of the potatoes?

Now, find the weights of other things – a brick, a book, a stone, etc.

Then, put a 2-kg weight on the small pan and put potatoes in the large pan so that the two pans are balanced. Your teacher will show you how to do this. What is the weight of the potatoes?

Weigh out 1 kg, 3 kg and $\frac{1}{2}$ kg of potatoes.

Using a spring balance

Hang a bucket on the hook of a *spring balance*. You notice that the spring stretches a little and the pointer moves down the scale to show the weight of the bucket.

Fill the bucket with potatoes. The spring stretches even more. What is the weight of the bucket and the potatoes together?

What is the weight of the potatoes?

Weight and gravity

The spring of the spring balance was stretched downwards by the weight of the bucket of potatoes. The bucket of potatoes was pulled towards the earth by its force of gravity. The pull of the earth's gravity on the bucket is its weight.

If the bucket of potatoes were taken right out into space well away from the force of the earth's gravity, it would have no weight at all. This may seem strange, but it is very true. The greater the pull of gravity on a thing, the larger is its weight.

On the moon, you could jump 6 times higher than you can on the earth because the moon's gravity is only 1/6 of that of the earth. You would weigh 6 times less.

Making a spring balance

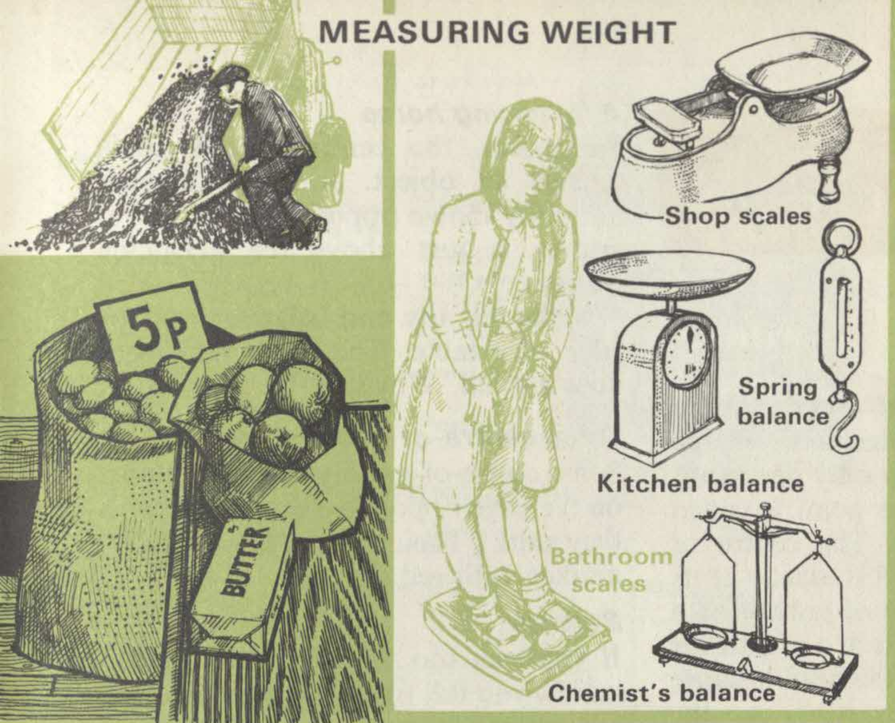
Make a spring balance in the way shown opposite.

MORE THINGS TO DO

1. Draw a kitchen balance.
2. Copy the table of weight measures.
3. Suppose that a man, weighing 72 kg on the earth, is on the moon. Work out his "moon weight".

Weight

MEASURING WEIGHT

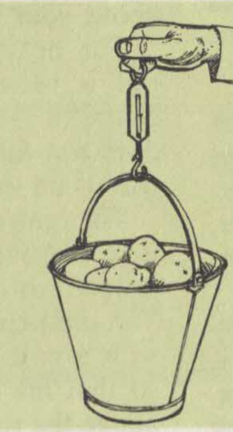


WEIGHT MEASURES

10 milligrammes (mg)	= 1 centigramme (cg)
100 centigrammes	= 1 gramme (g)
1000 milligrammes	= 1 gramme
1000 grammes	= 1 kilogramme (kg)
1000 kilogrammes	= 1 megagramme (Mg)
1 000 000 grammes	= 1 megagramme

USING SHOP SCALES

USING A SPRING BALANCE



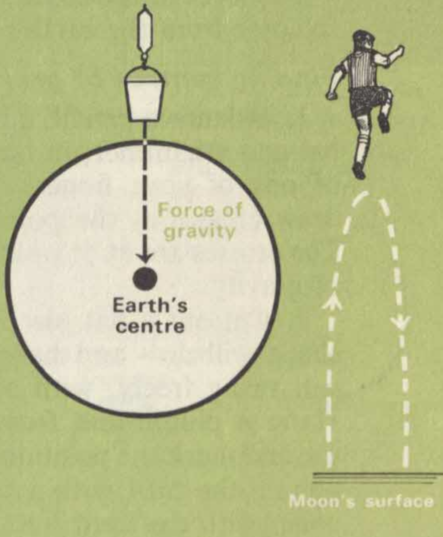
A little sum

Weight of bucket and potatoes =

Weight of bucket =

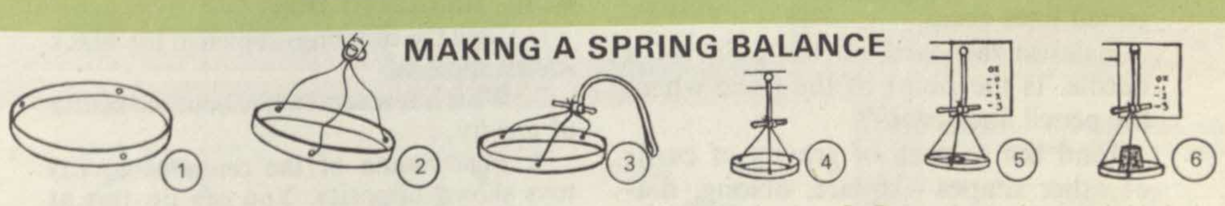
Weight of potatoes =

WEIGHT AND GRAVITY



Weight is the force of gravity

MAKING A SPRING BALANCE



1. Use a hammer and a nail to make 3 holes in the side of a cheese-box.
2. Tie 3 cotton threads to the holes. Tie the loose ends of the cotton together.
3. Tie the cotton to an elastic band and a match-stick for a pointer.
4. Hang the balance from the edge of a table with a drawing pin.
5. Fix a sheet of paper behind the balance. Make a scale by putting weights of 10 g, 20 g, etc., in turn, in the pan.
6. Weigh small objects.

26 The centre of gravity

Where does gravity attract?

An object always behaves as if the earth's gravity attracts only one point within the object. This point is called the *centre of gravity*. The centre of gravity of a billiard ball is exactly at its centre. But, the centre of gravity of a hammer is in the handle at a point near to where it is fixed to the head because the head is nearly as heavy as the handle.

The force of the earth's gravity seems to come from the earth's centre.

Finding centres of gravity

1. Balance a pencil, a ruler, a cricket bat and a hammer, in turn, on the end of one of your fingers. Use chalk to draw crosses at the points of balance. The crosses are at or near to the centres of gravity.

2. Cut out a flat piece of card – any shape will do – and hang it, so that it can swing freely, with a drawing pin. Hang a plumb-line from the drawing pin and mark the position of the plumb-line on the card with a pencil. Do this again with the card hung from one of its other corners. The centre of gravity of the card is at the place where the two pencil lines cross.

Balance the card on the point of a needle. Is the point at the place where the pencil lines cross?

Find the centres of gravity of cards of other shapes – square, oblong, diamond, triangle, etc.

A balancing horse

Sometimes, the centre of gravity is outside an object. In the balancing horse toy shown opposite, the centre of gravity is just above the plasticine weight.

Make this toy and balance it on the edge of a table. The horse rocks but does not fall. Why?

Some centre-of-gravity toys

Some centre-of-gravity toys are shown on the page opposite. Can you see how they work? Their centres of gravity are marked with red crosses.

Balance

If you lean too far backwards or forwards, you fall over. We say that "you lose your balance". You keep your balance when your centre of gravity is above your feet.

The heavy part of a double-decker bus is between its wheels and so its centre of gravity is low down. The bus does not fall over when it sways as it travels on the curved surface of a road.

The centre of gravity of an aeroplane is just above its wheels. On taking-off, it does not overbalance and crash.

A tight-rope walker keeps his balance with a pole. He moves the pole about so that his centre of gravity is always above the rope.

Why is it hard for a person on stilts to keep his balance?

Why is it foolish to stand up in a canoe or a small rowing boat?

MORE THINGS TO DO

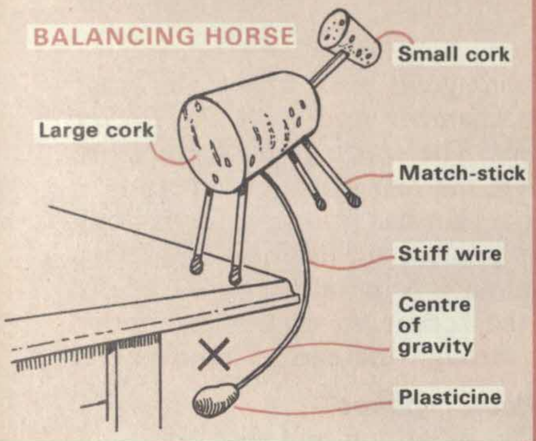
1. Copy the drawings shown in the black frame opposite.

2. Write a few sentences about the centre of gravity.

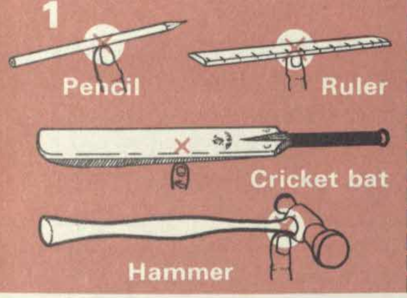
3. Make some of the centre-of-gravity toys shown opposite. You can do this at home.

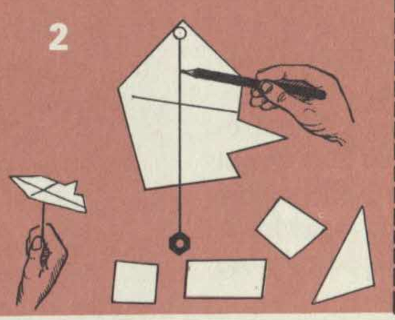
The centre of gravity

BALANCING HORSE

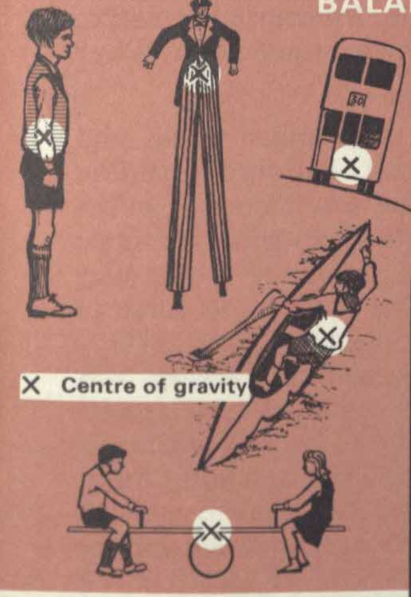


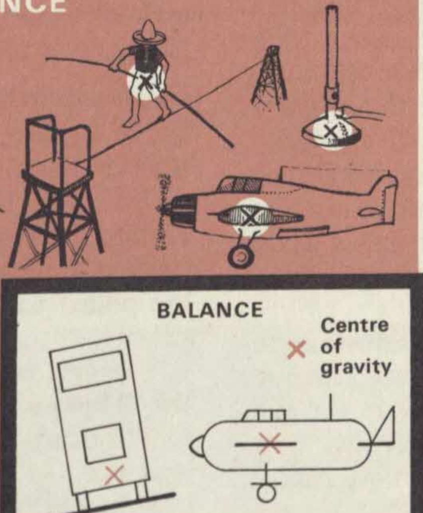
FINDING CENTRES OF GRAVITY



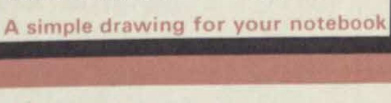


BALANCE

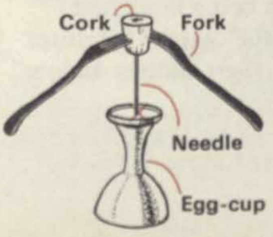


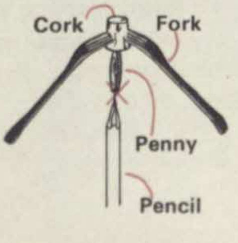


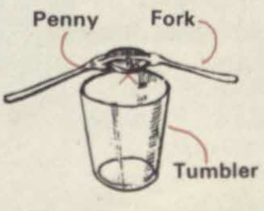
BALANCE



A simple drawing for your notebook

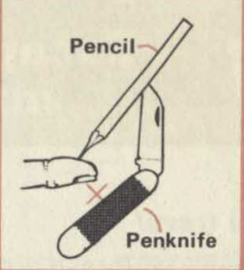


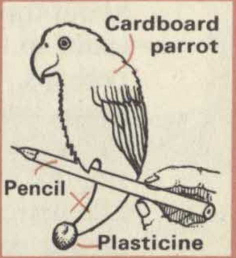


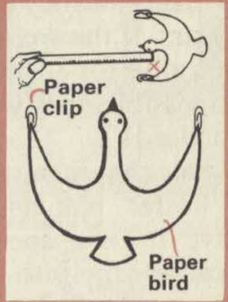


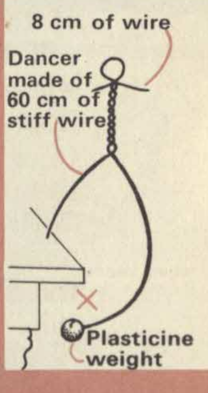
SOME CENTRE-OF-GRAVITY TOYS

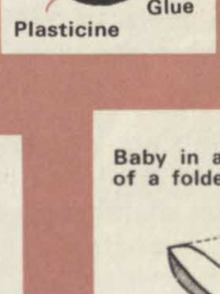
× Centre of gravity



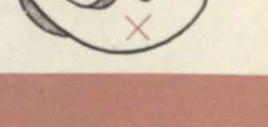








Baby in a cradle cut out of a folded circle of card



27 Escape into space

Space travel

For many years, scientists have thought about travelling from the earth through space to the stars and the planets. But, perhaps, it will never be possible for space travellers to reach the stars because they are so far away. The nearest star to the earth is 40 000 000 000 000 kilometres away. At a speed of 16 kilometres per second (138 000 kilometres per hour), this journey would take about 80 000 years. If the space travellers were to remain alive for 80 000 years, which is quite impossible, they would be very old people indeed!

It is likely that men will travel to some of the nearer planets. The travellers will have to use special *space ships* which can escape into space well away from the pull of the earth's gravity. Once away from the earth's gravity, these ships will be almost weightless. Their crews will be weightless too, and, unless he is strapped down, a space traveller will float about inside his space ship.

A few years ago, the Russians launched a *space capsule* into an orbit around the planet Venus. There were no men inside the capsule. It should have gone near to Venus on 13 May, 1961, but its radio failed to operate and so no one knows what has happened to it.

How a space ship moves

A space ship is really a very large rocket. At the back end, there is an explosion chamber in which a mixture of fuel and oxygen burns. The hot, expanding gases push against the front of the chamber and drive the rocket upwards. The waste gases escape from a hole in the rear of the chamber.

The rocket has a long, smooth body and is pointed at its front end. This streamlining helps air to flow rapidly over the rocket so that it can move easily through the earth's atmosphere.

A balloon "rocket"

Blow up a balloon and then let it go. It flies about. Why?

Streamlining

Hold a small book between a lighted candle and your mouth. Blow on the book. Is the candle extinguished?

Replace the book with a jar and blow again. The candle is extinguished. It seems that you can blow through the jar. What really happens? Do this experiment again with three jars in a row.

Place a small paper pellet inside the neck of a bottle. Blow into the bottle. The pellet is blown out and not in. Why?

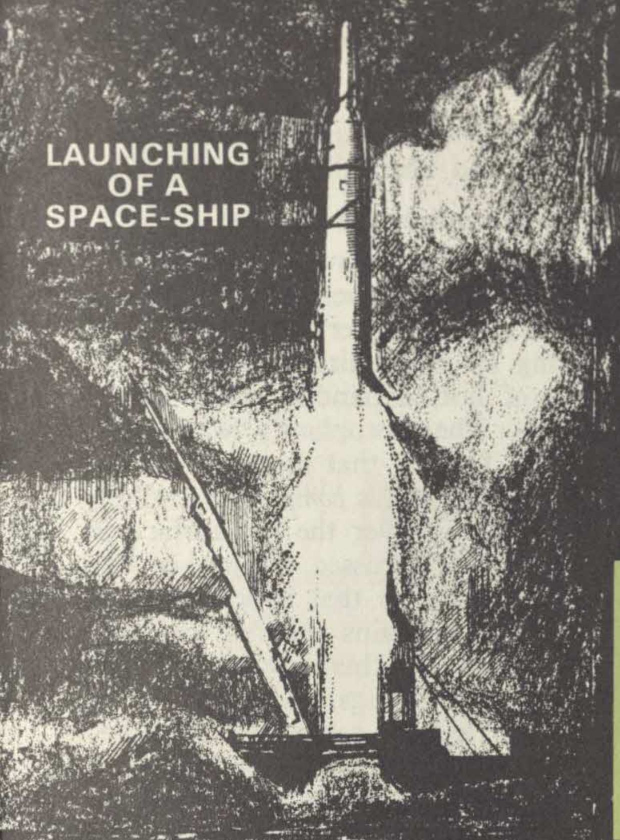
Earth satellites

Great Britain, the United States and Russia have all launched *satellites* which travel like tiny moons in orbits around the earth. They travel for some time and then, on losing speed, they are pulled to the earth by its force of gravity.

The first man to orbit the earth was the Russian astronaut, Yuri Gagarin. On 12 April, 1961, he took off in his space ship at 9 o'clock and, after orbiting the earth at 29 000 kilometres per hour, he landed at 11 o'clock on the same day.

MORE THINGS TO DO

1. Draw a space ship being launched.
2. Draw some of the earth satellites shown opposite. Print their names below them.

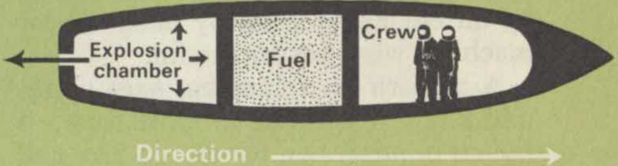


LAUNCHING OF A SPACE-SHIP

Escape into space

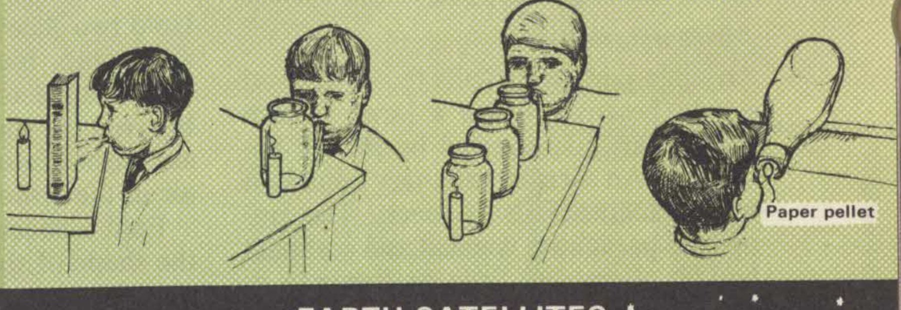
A space traveller is weightless

HOW A SPACE SHIP MOVES



BALLOON "ROCKET"

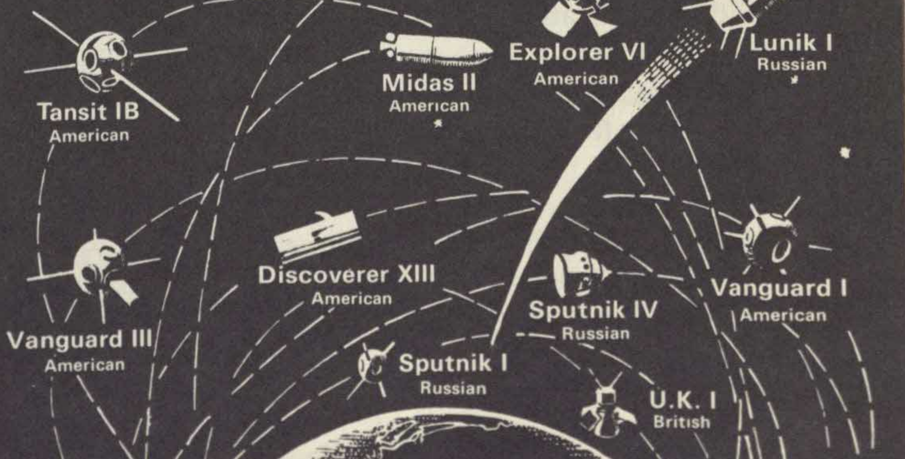
STREAMLINING



THE FIRST ASTRONAUT

YURI GAGARIN
The Russian Space Flyer
Orbited the earth
12th April, 1961

EARTH SATELLITES



28 Copying the birds

Flight

What do you notice when you watch the flight of a bird? The bird has large wings by which it can hover and glide. It flies by flapping its wings in a way that could be called "rowing in air".

In their first attempts at flight, men tried to copy the birds. Some of the earliest designs of flying machines had moving wings which were made to flap by an engine or even by hand. These machines were not successful.

A modern aeroplane has fixed wings and a tail. It is made to move forward by *jets* or *airscrews*, which you may call "propellers".

Some men have managed to glide by means of wings strapped to their arms.

Air resistance

An open parachute falls to the ground slowly because it has a large surface that is partly supported by the air beneath it. An airman falls very quickly if his parachute fails to open. The unopened parachute is small and compact and air offers very little resistance to it.

Air resistance helps birds, gliders and aeroplanes to keep aloft. Their wings are partly supported by the resistance of the air beneath them.

Showing air resistance

Drop a marble and a feather together. The feather falls slower than the marble. Why is this?

Making a paper glider

Make a glider from a 15-centimetre square of paper in the way shown opposite.

Throw it into the air. It flies for some distance and then falls slowly. Why?

How aeroplanes rise

Aeroplanes are heavier than air but they are able to rise. An aeroplane is pushed forward either by a stream of fast moving air from airscrews or by the force of hot, expanding gases in jet engines. The aeroplane's wings are slanted. The air that meets the lower surface of a wing is *compressed* and the air that flows over the top surface is thin. The compressed air pushes the wing upwards so that it occupies the space that contains thin air. Airmen have a name for this upwards push on an aeroplane's wings. They call it *lift*.

A kite rises the same way. The kite, held at an angle by two strings, is pulled along very quickly. The air compressed by its lower surface pushes it upwards.

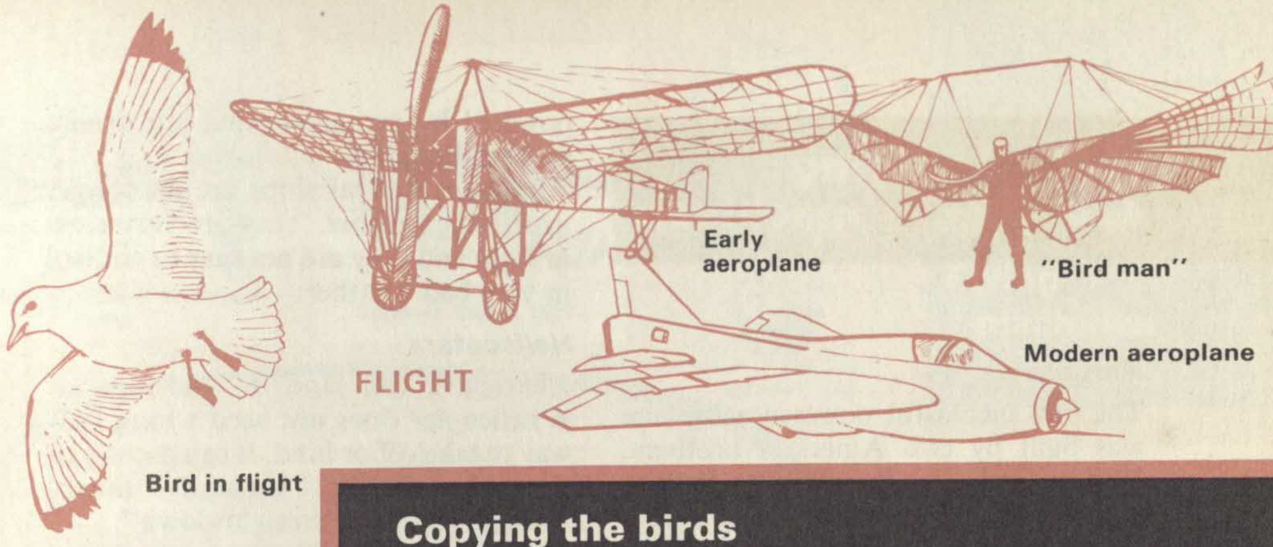
Thin air and lift

Hold two sheets of paper about an inch apart and blow between them. The sheets move together. The moving air between the sheets is thin and the sheets are pushed into it by the pressure of the air in the atmosphere.

Fold a sheet of paper so that it has the shape of the upper side of an aeroplane's wing. Place the paper on a table and blow across the curved surface. The paper rises into the stream of moving air. Why?

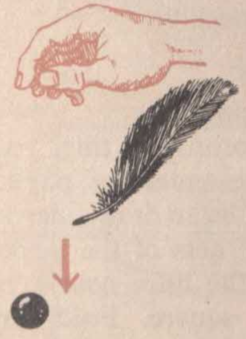
MORE THINGS TO DO

1. Copy the drawings shown in the black frame opposite.
2. Write a short essay with the title *Flight*.
3. Look up the word "compressed" in a dictionary and find out what it means.
4. Make a kite in the way shown opposite. You can do this at home.

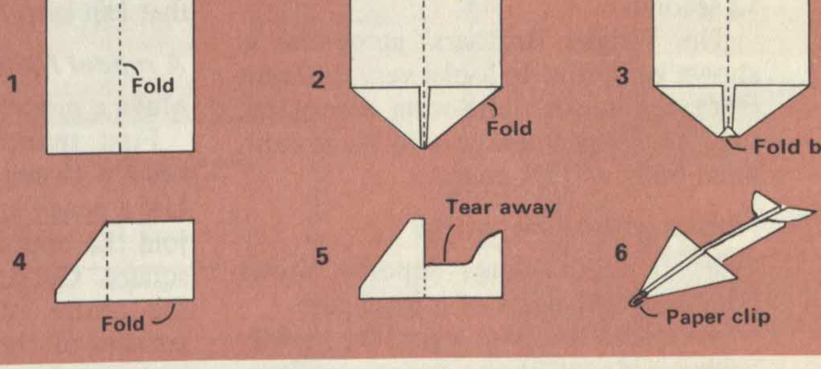


Copying the birds

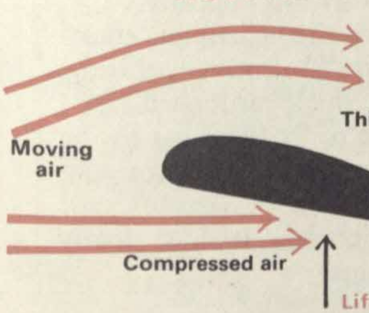
AIR RESISTANCE

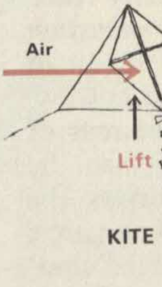


MAKING A PAPER GLIDER



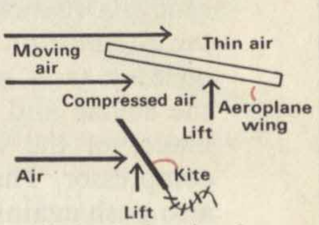
HOW AEROPLANES RISE





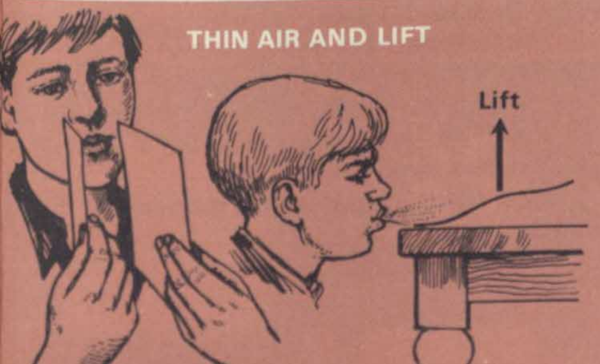
KITE

HOW AEROPLANES RISE

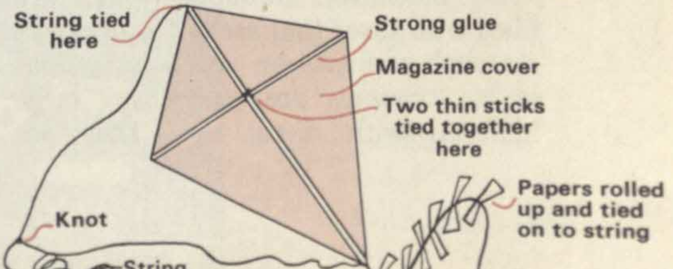


A simple drawing for your notebook

THIN AIR AND LIFT



MAKING A KITE


String tied here
Strong glue
Magazine cover
Two thin sticks tied together here
Papers rolled up and tied on to string
Knot
String

29 Flying machines

Aeroplanes

The first successful powered aeroplane was built by two American brothers, Wilbur and Orville Wright. It was powered by two sets of turning blades that were driven by a petrol engine. The first flight was made at Kitty Hawk, North Carolina, in 1903. It lasted for 12 seconds.

The Wright Brothers' aeroplane is shown opposite. It looks very different from a modern delta-wing aeroplane, like the Avro Vulcan, with its streamlined body and jet engines.

How a jet engine works

One of the drawings opposite shows the important parts of a jet engine.

Air enters the *nose* where the rapidly spinning blades of the *compressor* force it at a high pressure into the *combustion chamber*. Jets of fuel burn in the air in the combustion chamber. The hot, expanding gases escape from the rear of the engine and, in so doing, turn the blades of the *turbine* that drives the compressor. The hot, expanding gases, also push against the front of the combustion chamber and so the engine is made to move forward.

Balloons and airships

Aeroplanes are not the only kinds of flying machines. Balloons, which are filled with gases that are not as heavy as air, such as *hydrogen* and *helium*, float in air. *Airships* are really very large balloons with metal ribs. They are powered by propellers that are driven by petrol engines.

Balloons and airships are no longer used for transport. They are very slow in flight and they are not easy to control in very bad weather.

Helicopters

Helicopters can land in small spaces. A helicopter does not need a long runway to take off or land. It can ascend or descend vertically. "Vertically" means "straight up" or "straight down".

A helicopter is lifted by a *rotor* that is driven by a petrol engine. The blades of the rotor are reallv slender wings that can turn very quickly.

A model helicopter

Make a model helicopter.

First, make the rotor. For this, you need a 15-centimetre square of paper. Use a pencil and a ruler to draw lines to join the opposite corners of the paper square. Cut down the lines nearly to the centre of the square. Fold the corners of the square over the centre and gum them where they overlap. The way to do this is shown opposite.

Cut the body of the helicopter, cigar-shaped and about 15 centimetres long, out of a piece of thick cardboard.

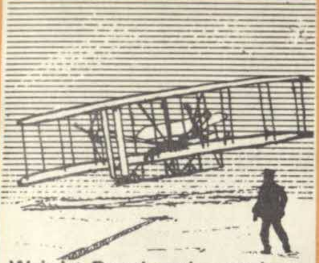
Use a long pin to fix the rotor to the body. Make sure that the rotor can turn freely on the pin.

Drop the helicopter. It falls slowly and the rotor spins.

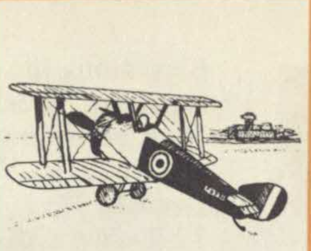
MORE THINGS TO DO

1. Use tracing paper to copy some of the drawings of flying machines shown opposite. Print their names below them.
2. Copy the simple drawing of a jet engine shown opposite.
3. Find North Carolina on a map of the United States.

Flying machines



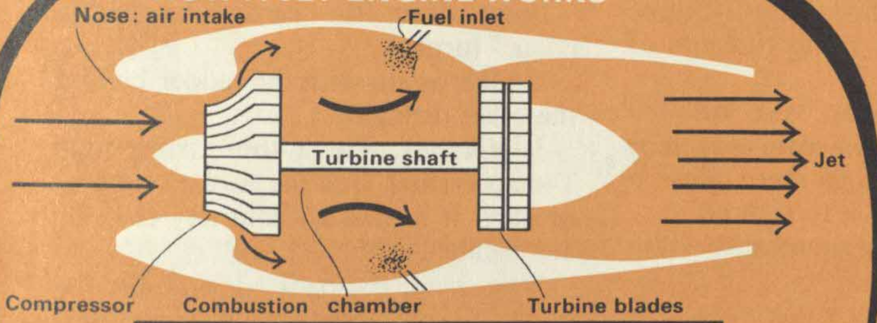
Wright Brothers' aeroplane, 1903

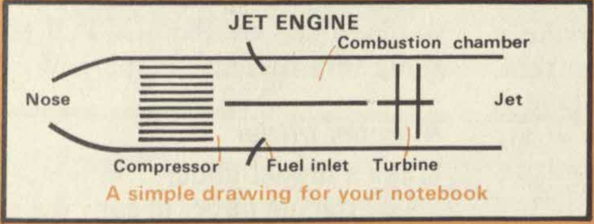


Sopwith Camel, 1917

Professor Charles' balloon, 1783

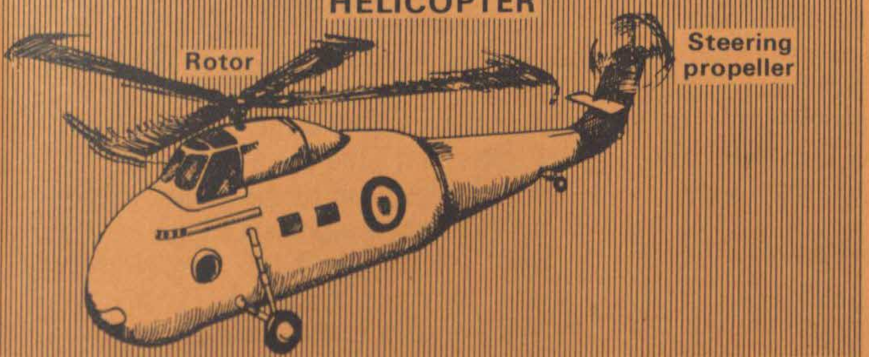
HOW A JET ENGINE WORKS



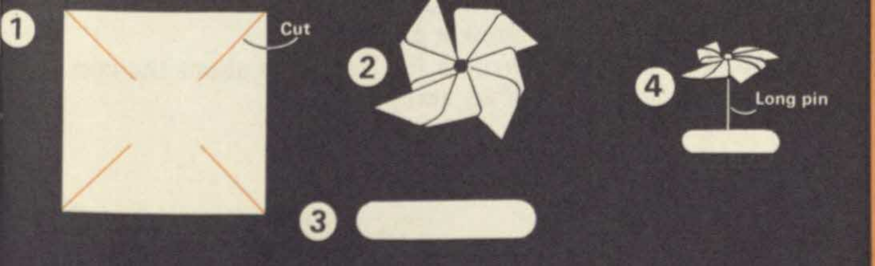


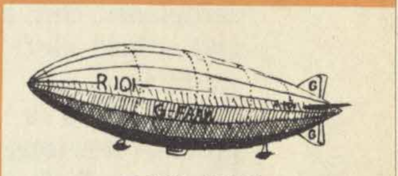
A simple drawing for your notebook

HELICOPTER



MODEL HELICOPTER

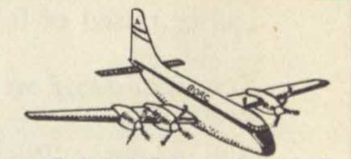




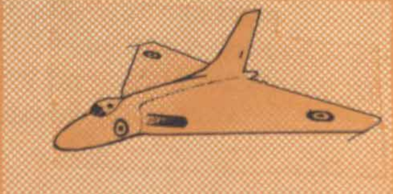
R 101, 1926

Gloster Gladiator, 1936

Gloster Meteor, 1944



Bristol Britannia, 1952



Avro Vulcan, 1960

30 A model glider

Gliders

Gliders are built in the same way as aeroplanes. But, a glider has no engine and is held aloft by rising currents of warm air.

How does a glider take off the ground? It is towed by a team of men or a motor-vehicle until its speed gives it enough lift to enable it to take off.

Gliding is a popular pastime.

How an aeroplane is controlled

No doubt, you would like to make a model glider, but, before you do that, you should learn how an aeroplane is controlled. The controls of a glider are nearly the same as those of an aeroplane.

An aeroplane is turned to the left or to the right by a *rudder*.

It is made to ascend or descend by an *elevator*. When the elevator is raised, it meets a stream of moving air and the aeroplane is forced to ascend.

Ailerons enable an aeroplane to turn and bank. "Bank" means "tilt". They are on the back edge of the wings. They can be raised or lowered separately.

The actions of an aeroplane's controls

1. *Elevator*. Push a pin through the centre of a card, about 8 cm long and 2 cm wide. Make sure that the card can turn freely on the pin. Then, push the point of the pin into a cork. Bend up the end of the card so that it will act as an elevator.

Blow along the card. The front of the "aeroplane" rises. Why?

Now, bend down the end of the card. Blow along it. What happens to the "aeroplane"?

2. *Rudder*. Cut a slit in a card, about 8 cm long and 2 cm wide. Bend the end of the card to make a rudder in the way shown opposite. Mount the card on a cork as you did with the elevator.

Blow along the card. The "aeroplane" turns.

Do this again with the rudder bent in the other direction.

3. *Ailerons*. Tie a thin string to a T-shaped card. Pull the card along very quickly. It moves without any twisting or turning.

Now, bend the back edges of the top of the T, one upwards and one downwards, to act as ailerons. Pull the card along very quickly. It spins. Why?

A model glider

Make a model glider.

Use tracing paper to copy the parts of a glider shown opposite on to a sheet of thin cardboard. Cut out these parts. Also, cut two slots where shown.

Use a penknife to score lines on the tail fin and wing to make a rudder and elevators.

Slide the wing and the tail wing into their slots and glue them in place.

Weight the nose of the glider with a lump of plasticine or paper clips.

Bend the wing and tail wing slightly so that they are V-shaped. Tie a large rubber band to a stick to make a catapult. Use it to launch the glider.

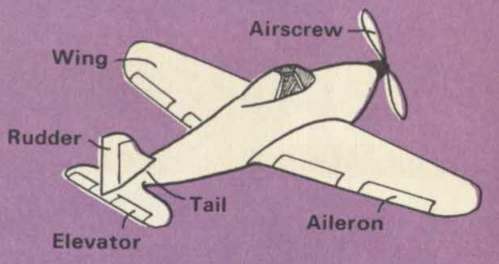
MORE THINGS TO DO

1. Draw a glider.
2. Write a few sentences about the controls of an aeroplane.

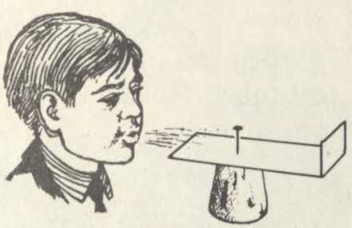
A model glider

GLIDERS

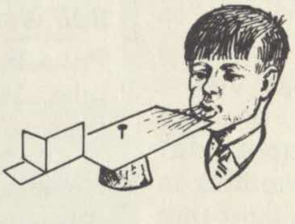
CONTROLLING AN AEROPLANE



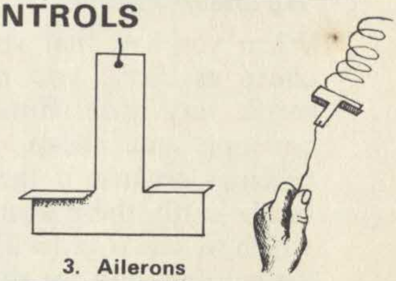
ACTIONS OF AN AEROPLANE'S CONTROLS



1. Elevator

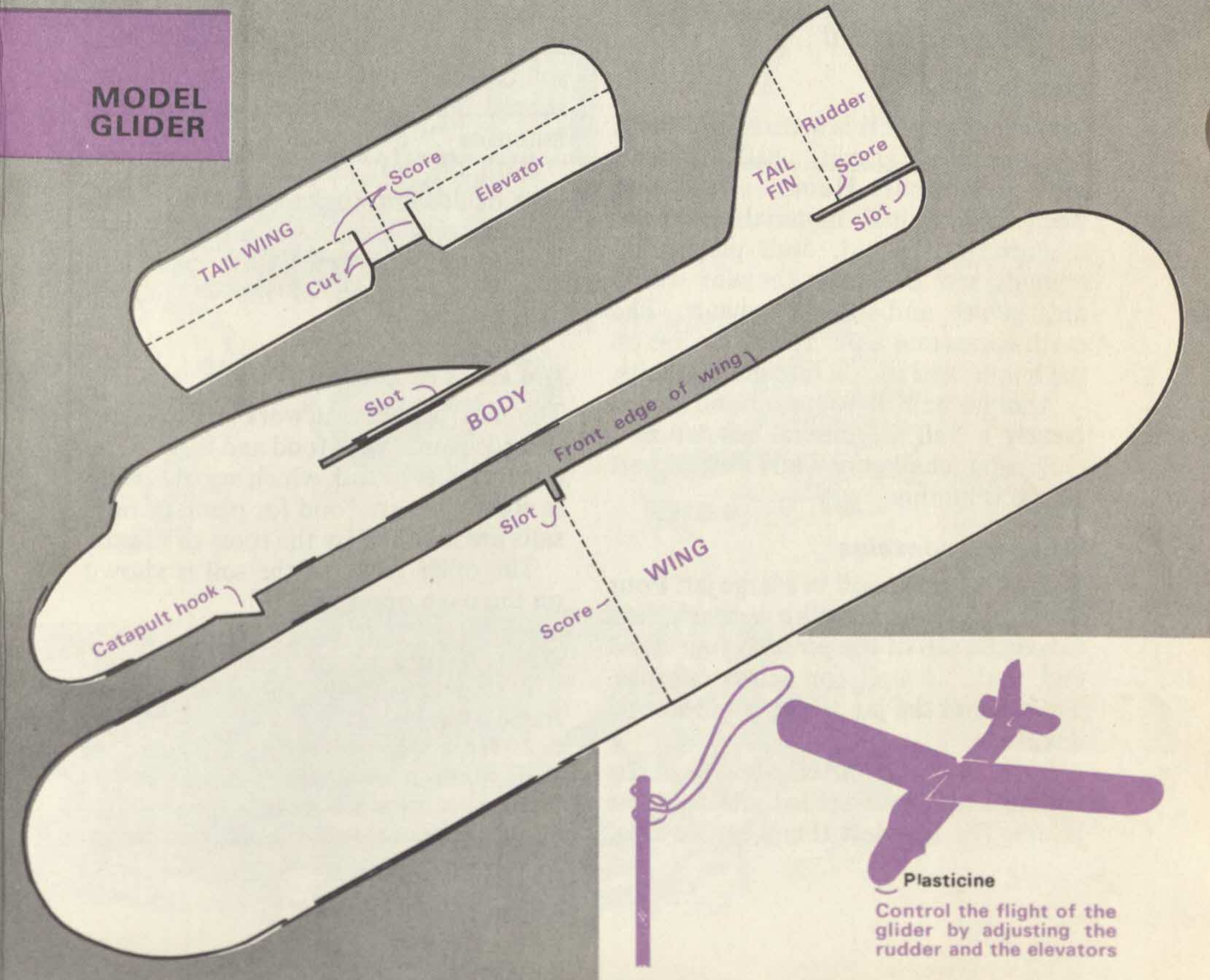


2. Rudder



3. Ailerons

MODEL GLIDER



Control the flight of the glider by adjusting the rudder and the elevators

31 Soil

"As cheap as dirt"

When you say that something is "as cheap as dirt", you mean that it is worth very little. But, though dirt is common and cheap, it is also very precious because if there were no dirt on the earth, there would be nothing in which we could grow all the plants that we need as food for ourselves and our farm animals. Of course, dirt is just another name for *soil*.

What is soil?

But, what is soil? It is a mixture of sand, clay, pebbles, gravel, chalk, mineral salts and *humus*. Humus is decaying plant and animal materials, such as manure, leaf-mould, dead plants and animals, etc. Soil also contains water, air, *germs* and small animals, like earthworms and ants. The germs live on the humus and turn it into mineral salts.

About a half of soil is air and water. Nearly a half is mineral substances – clay, sand, chalk, etc. Only a small part of soil is humus.

What soil contains

Put some garden soil in a large jar. Pour water into the jar until it is nearly full. Cover the top of the jar with your hand and shake it well for a few minutes. Then, stand the jar where it will not be disturbed.

Look at the jar after a few days. Its contents will have settled into separate layers. The heaviest things settled first. The humus floats on the surface of the water. The mineral salts are dissolved in the water.

Very gently, pour a little of the water from the jar into a test-tube. Heat the test-tube until all the water has boiled away. Notice the thin grey-white film of mineral salts around the inside of the tube.

Soil water

Put a little "dry" garden soil in a test-tube. Heat the test-tube. Notice the "steam" that escapes from it.

How soil is made

When you look at the side of a deep trench dug in a garden, you see a top layer of soil, a layer of *subsoil* below it, and a bottom layer of rocks. The soil is usually darker in colour than the subsoil. The subsoil contains very little humus.

Both the soil and the subsoil have been made from rocks which have been broken up by the action of the weather – rain, running water, frost, heat and wind. This action of the weather is called *weathering*.

The work of the soil

The most important work of soil is to provide plants with food and water. The mineral salts in soil, which are dissolved in soil water, are food for plants. These salts are taken in by the roots of plants.

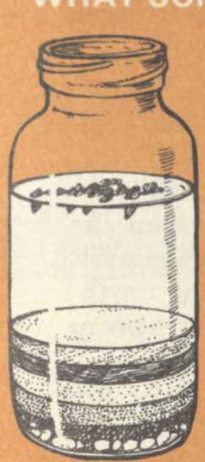
The other work of the soil is shown on the page opposite.

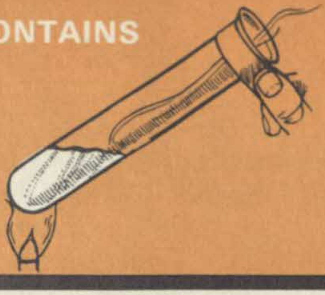
MORE THINGS TO DO

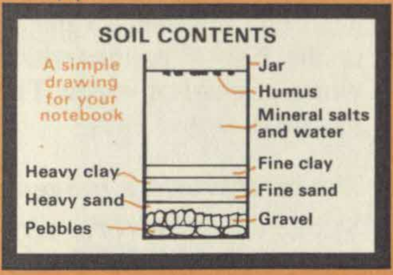
1. Copy the drawing shown in the black frame opposite.
2. Write one sentence about each of these words in a way which shows that you know what the word means.
Humus; manure; soil; subsoil; weathering.

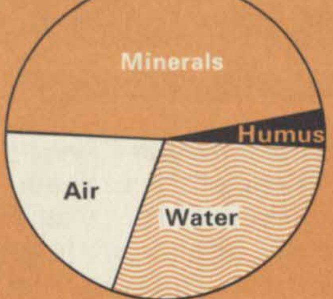
Soil

WHAT SOIL CONTAINS

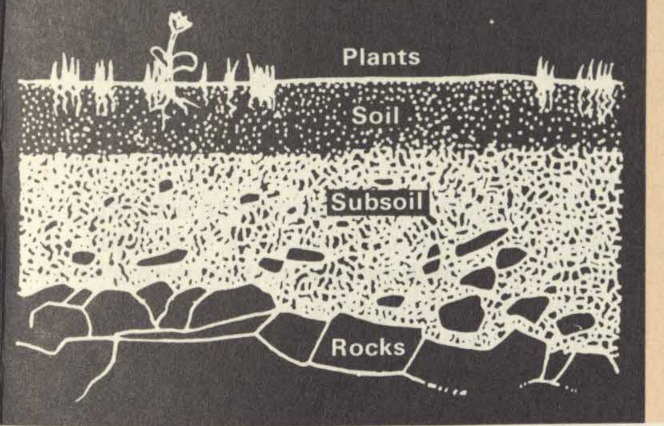








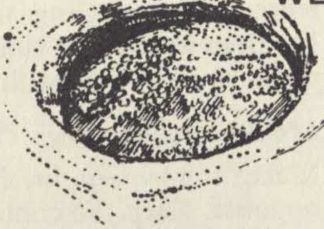
SOIL LAYERS



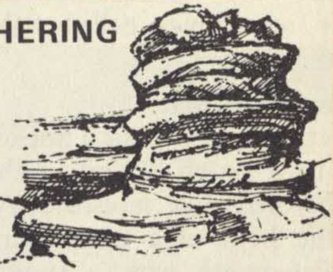
SOIL WATER

WEATHERING

Rocks shattered by expanding ice



Hole in a rock made by running water



Rocks worn away by sand carried by winds

Rocks broken and worn by the force of wind and water in a storm

THE WORK OF SOIL

1. Cover

Soil covers and protects delicate shoots

2. Darkness

Seeds germinate best in darkness

3. Holding

Roots grow between soil and rocks and so are held in place even in strong winds

4. Warmth

Soil is an insulator and protects roots and bulbs against extremes of heat and cold

5. Air

Spaces in the soil contain air which is breathed by roots and germs

6. Water

Roots take in the water that the soil contains

7. Food

Mineral salts in the soil water are taken in by roots

32 "The little ploughman"

The work of the earthworm

The *earthworm* is one of the many animals that live in the soil. It is a most important animal because it helps farmers and gardeners by doing a lot of useful work in the soil.

The earthworm burrows in the soil and, in so doing, makes many holes which enable water to drain through the soil and allow air to reach the roots of plants. Plant roots breathe the air in the soil. The earthworm feeds on decaying vegetation, and the waste from its body, which it leaves behind as *casts,* is a good food for plants. In burrowing, the earthworm loosens and mixes the soil. We can say all this in a few words as: the earthworm *drains, aerates, manures* and *ploughs* the soil.

The earthworms in a small field can lift as much as 25 000 kilogrammes of soil every year. No wonder that the earthworm is sometimes called "the little ploughman".

Collecting earthworms

When the weather is dry, pour a bucket of water on to a patch of soil in the garden. Earthworms like moisture. At night, with the help of a torch, turn over the moist patch with a spade. Collect a few earthworms and put them and some moist moss in a jar with a lid.

Looking at an earthworm

Place a large earthworm in a small dish and look at it closely.

Notice that its body is long, thin and round and is divided into about 150 *segments*. The dark, pointed end is the head; the pale, flat end is the tail.

Feel its skin. It is slimy. The earthworm breathes through its moist skin. It soon dies if its skin becomes dry.

Examine the worm under a magnifying glass. Look for the mouth in the head and the *anus* in the tail. The anus is the hole through which the earthworm gets rid of waste. The earthworm has no eyes and ears.

The earthworm's movements

Stroke the earthworm very gently. Can you feel the bristles which give it a hold on a surface? There are 8 bristles on each segment.

Place the earthworm on a sheet of rough paper. Listen carefully and, as the worm crawls, you will hear its bristles scraping the rough surface of the paper.

Then, place the earthworm on a sheet of glass. It tries to crawl but it does not make very much progress. Why is this?

Place the worm on a wooden bench. When the worm is crawling, clap your hands. The earthworm carries on crawling. It cannot hear the hand clap. Why? Then, bang your fist on the bench. The worm stops crawling and curls up. It has been startled. It can feel the movements in the bench with its skin.

Making a wormery

Make a *wormery* in the way shown opposite. Keep the contents moist.

After a week, you should see worm-casts, burrows and mixing of the soils.

MORE THINGS TO DO

1. Draw an earthworm. Label each part.
2. Draw a worm-cast.
3. Copy this sentence.

The Work of Earthworms

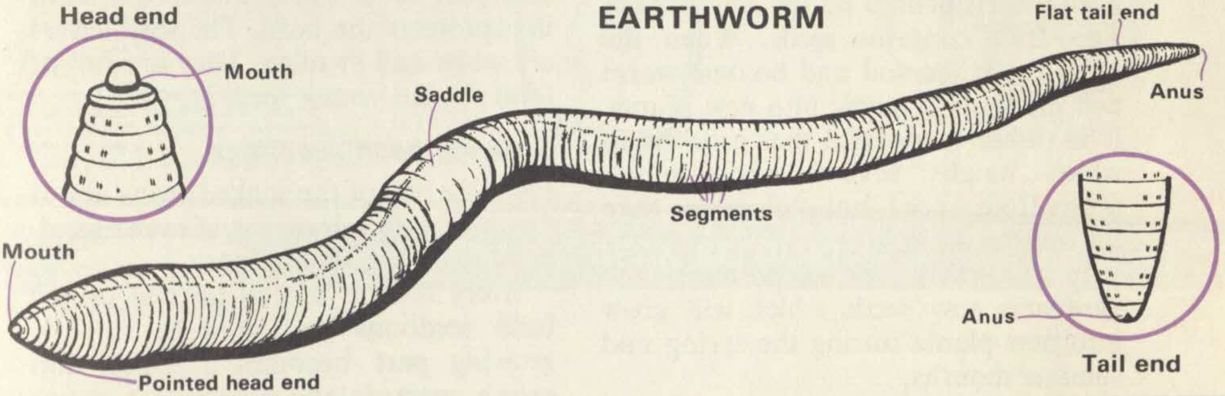
Earthworms drain, aerate, manure and plough the soil.

"The little ploughman"

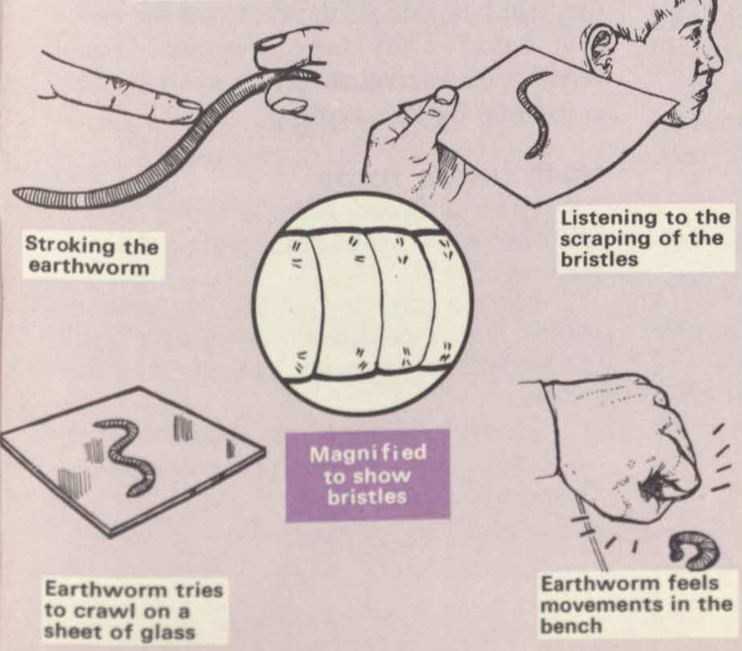
Worm-cast

The earthworm drains, aerates, manures and ploughs the soil

EARTHWORM



THE EARTHWORM'S MOVEMENTS



Stroking the earthworm

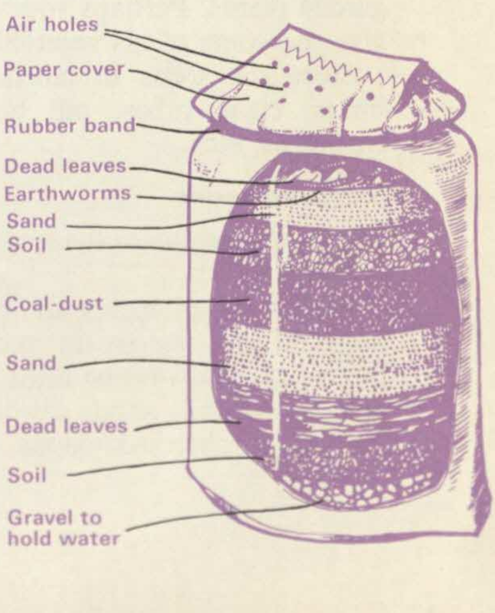
Listening to the scraping of the bristles

Magnified to show bristles

Earthworm tries to crawl on a sheet of glass

Earthworm feels movements in the bench

MAKING A WORMERY



33

Seeds

New plants

Plants are dying all the time. Some, like wheat and radishes, die after only a few months of life. But, even the trees, which live for many years, must die eventually. However, there are always new plants to take the place of those that die. The new plants grow from seeds. After a flower has withered away, a fruit is left behind on the *flower-stalk*. This fruit contains seeds. When the seeds reach the soil and become warm and moist, they grow into new plants. It is rather wonderful that a cabbage, which weighs several kilogrammes, grows from a seed that is no bigger than the head of a pin.

In the early spring, farmers and gardeners sow seeds which will grow into new plants during the spring and summer months.

Collecting seeds

Collect seeds of all kinds from wild and garden plants. Perhaps your father will give you some of his vegetable seeds.

Store the seeds in labelled matchboxes, cigar tubes, pill boxes, jars, envelopes, etc.

Growing seeds

Try growing some of the seeds you have collected.

Plant a few of each kind about 5 mm deep in jars, ice-cream tubs, dishes, bowls, saucers, orange skins, etc. filled with moist soil, sand, sawdust, wood shavings or shredded paper.

The parts of a broad bean

Soak a few broad beans in a jar of water for about 24 hours.

Then, examine one of the beans. On the top of the bean, there is a *scar* in a groove. This is where the bean was once joined to the bean pod. Can you see a tiny hole just below the scar? This is where water enters the bean and where a root will appear when the bean begins to grow.

Squeeze the bean. A drop of water oozes from the hole below the scar.

Now, pull the bean to pieces with your fingers. You will see a *seed-coat*, two *seed-leaves* and a *growing part*. The seed-coat is a thick waterproof skin that protects the bean. The seed-leaves are white and swollen. They are full of food for the young seedling.

Growing bean seedlings

Plant the rest of the soaked beans about 5 mm deep in a large jar of moist sand, sawdust or wood shavings.

Every few days, pull up one of the bean seedlings and examine it. The growing part becomes a shoot that grows upwards and a root that grows downwards. The shoot has leaves and the root has side roots. Can you see the *root hairs*? They take in water. The seed-leaves shrivel as the food in them is used up by the seedling.

MORE THINGS TO DO

1. Draw a broad bean, a broad bean split open and a broad bean seedling. Label each part.
2. Make a marrow "garden", an indoor garden and a cotton wool "rockery" in the way shown opposite. You can do this at home.
3. If you have a pen-pal, send him (or her) some of your seeds in labelled packets. *Do not send seeds abroad.*

Seeds

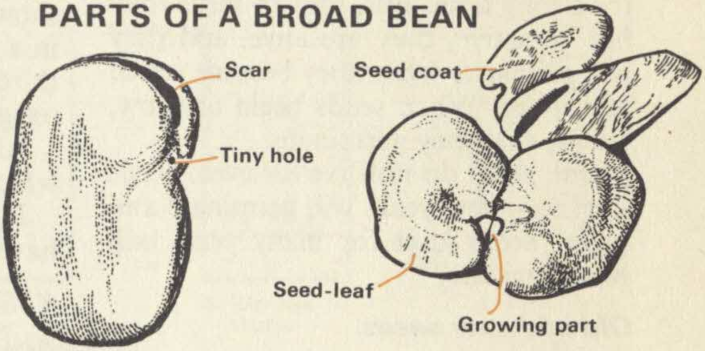
Seeds being sown by hand

Seeds being sown by a modern seed drill

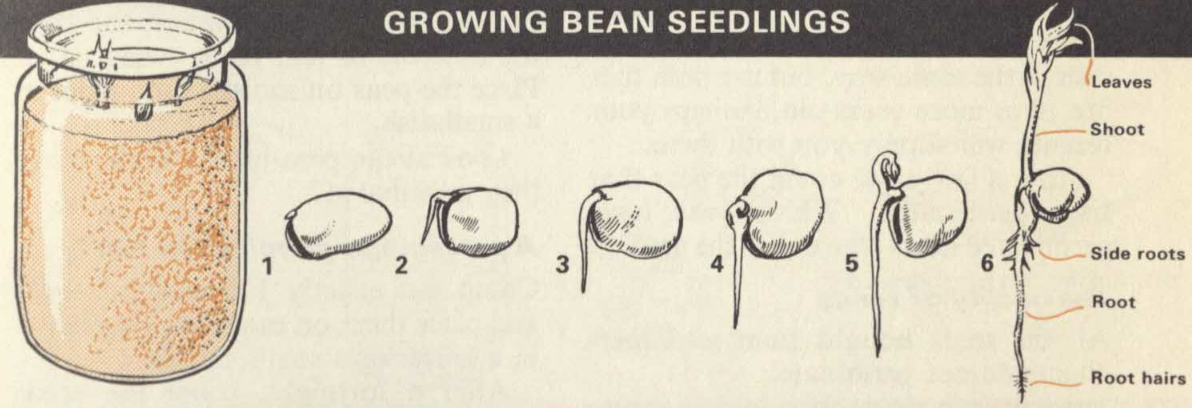
GROWING SEEDS

Some seeds to grow:—
Orange; apple; grass; maize; pea; cress; mustard; radish; onion; turnip; cabbage; wheat; oats; sunflower; marrow; marigold; runner bean; shepherd's purse.

PARTS OF A BROAD BEAN



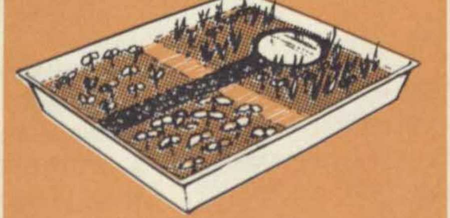
GROWING BEAN SEEDLINGS



MARROW "GARDEN"

Use a nail to make small holes in the skin of a marrow. Soak small seeds – radish, mustard, grass, etc. – in water for 24 hours. Then push the seeds into the holes. From where do the young seedlings get water?

INDOOR GARDEN



Fill a large dish with moist soil. Make paths of sand and gravel. Use a mirror for a pond. Plant small seeds here and there.

COTTON WOOL "ROCKERY"

Make a "rockery" from wet cotton wool. Wet cotton wool can be moulded into any shape. Sprinkle small seeds here and there.

34 Germinating seeds

Seeds are alive

Seeds are dry and can be stored away for a long time. But, though seeds may not be active, they are alive, and they will *germinate* when they become warm and moist. When seeds begin to grow, we say that they germinate.

But, seeds do not live for ever. Seeds kept for a few years will germinate and grow. Seeds kept for many years will not germinate.

Old and new seeds

Soak 20 peas from last year's plants in a jar of water for 24 hours. Place the peas on moist cotton wool or blotting paper in a small dish. Prepare another dish in the same way, but use peas that are 10 or more years old. Perhaps your teacher will supply you with these.

After a few days, count the peas that have germinated. Which peas have germinated best – the old or the new?

The quality of seeds

All the seeds bought from seed merchants do not germinate.

Some seeds do not germinate because they are planted in either cold or very dry soil. Seeds will not germinate if they are cold or dry.

Some seeds do not germinate because they have been damaged by heat, disease and careless handling. The growing part of a seed is easily injured.

The British Parliament has made a law which says that seeds cannot be sold by a seed merchant unless they are of good quality. Samples of seeds are tested to make sure that most of them will germinate if they are planted in the proper way.

The conditions for germination

Place a layer of sand in the bottom of each of four jars. Place a few peas on each layer of sand. Arrange for the conditions in the jars to be as they are shown opposite. Keep the second jar in a refrigerator. The iron filings in the third jar will rust and use up all the oxygen inside it.

After a week, look at the peas. In which jar have the peas germinated?

If seeds are to germinate, they must have *water, warmth* and *air*.

Killing seeds

Boil a few peas in a test-tube of water. Soak a second lot of peas in a small jar of battery acid for three days. Soak a third lot in water for 24 hours, and then use a needle to tear the growing parts. Place the peas on moist cotton wool in a small dish.

Look at the peas after a week. Have they germinated?

A percentage germination test

Count out exactly 100 mustard seeds and place them on moist blotting paper in a saucer or a small, flat dish.

After a fortnight, count the seeds that have germinated. What percentage of the seeds have germinated? "Per cent" means "out of 100".

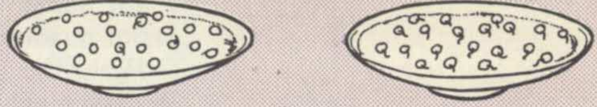
MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Work out the percentage germinations.

Seeds planted:	100	20,	50,	1000.
Seeds germinated:	98,	19,	40,	950.

Germinating seeds

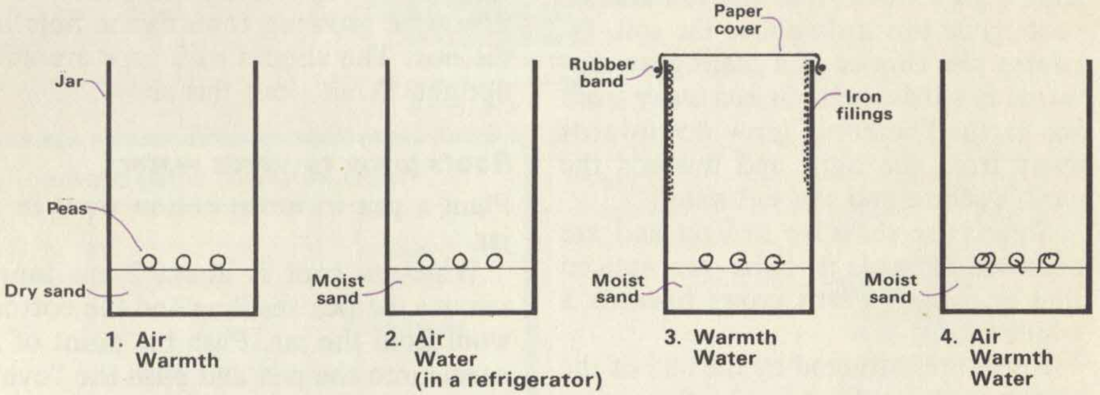
OLD AND NEW SEEDS



10 years old peas

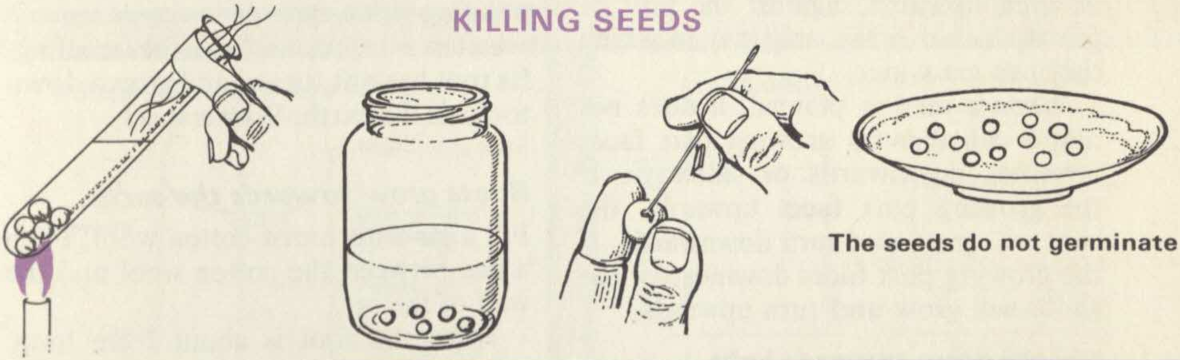
Last year's peas

CONDITIONS FOR GERMINATION



If seeds are to germinate, they must have water, warmth and air

KILLING SEEDS



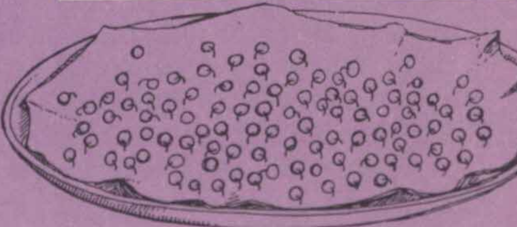
The seeds do not germinate

THE QUALITY OF SEEDS

On this packet of seeds, there are the words:

These seeds have been tested in accordance with the provisions of the Seeds Act, 1920. Germination and purity are not less than the minimum percentages authorised by the Seeds Regulations.

PERCENTAGE GERMINATION TEST



Number of germinating seeds = percentage germination

35 How plants grow

Plant growth

How odd a plant would look if its shoots grew down into the soil and its roots grew upwards above the soil. Of course, the shoots of a plant grow upwards towards the light and away from the earth. The roots grow downwards away from the light and towards the earth's centre and the soil water.

Shoots are sensitive to light and are attracted towards it. Have you noticed that an indoor plant grows towards a window?

Roots are attracted by the pull of the earth's gravity. That is why they grow downwards. But, roots are also attracted by water, and they will grow sideways, or even upwards, against the pull of gravity if that is the only way in which they can get water.

When a seed is planted, it does not matter whether its growing part faces upwards, downwards or sideways. If the growing part faces upwards, the root will grow and turn downwards. If the growing part faces downwards, the shoot will grow and turn upwards.

Shoots grow towards light

Plant a few peas, about 5 mm deep, in a jar of moist sand or soil. Make a small hole in the side of a cardboard box. When the pea seedlings have grown about 5 cm high, cover the jar with the box.

After a few days, remove the box. What do you notice about the pea seedlings?

Shoot tips are sensitive to light

Plant some wheat or oat grains in a jar of moist soil or sand.

When the seedlings have grown about an inch high, cover some of their shoots with caps made from foil from chocolate bars. Then, cover the jar with the cardboard box with a hole in its side.

After a few days, remove the box. The shoots without caps are bent over; they were growing towards the hole in the box. The shoots with caps are still upright. What does this show?

Roots grow towards water

Plant a pea in moist cotton wool in a jar.

When its root is about 2 cm long, remove the pea seedling and the cotton wool from the jar. Push the point of a needle into the pea and push the "eye" into some of the cotton wool. Support the cotton wool and the pea seedling in the mouth of the jar so that the root is pointing sideways.

After a week, look at the seedling. Its root has not turned and grown down towards the earth. Why is this?

Roots grow towards the earth

Fill a jar with moist cotton wool. Push a pea between the cotton wool and the wall of the jar.

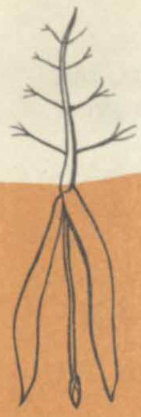
When the root is about 2 cm long, lay the jar on its side.

After a few days, look at the root. It has turned and is growing downwards. What does this show?

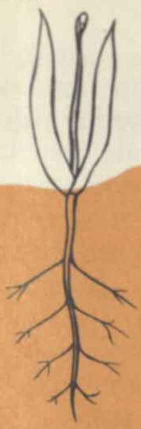
MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Grow a carrot "fern" in the way shown opposite. You can do this at home.

How plants grow

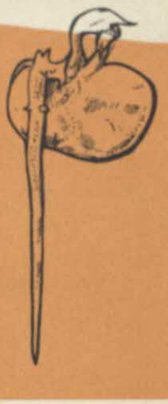


Do plants grow like this?



Shoots grow upwards and roots grow downwards

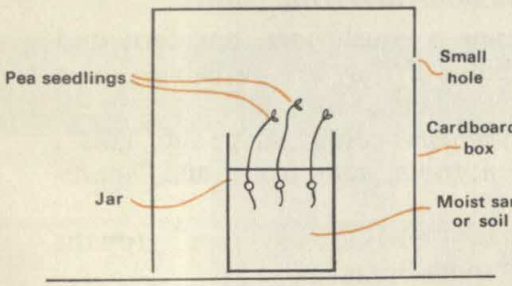
Indoor plants grow towards windows



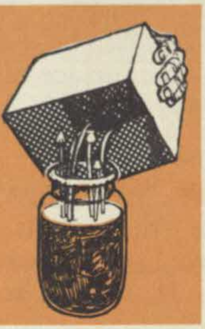
If the growing part faces upwards, the root grows and turns downwards

If the growing part faces downwards the shoot grows and turns upwards

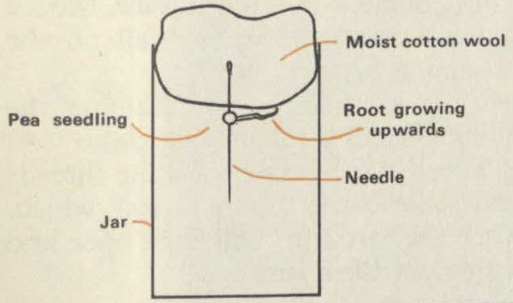
SHOOTS GROW TOWARDS LIGHT



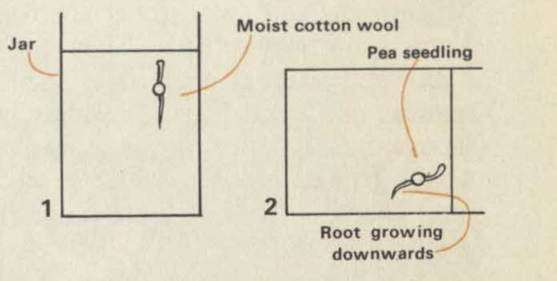
SHOOT TIPS ARE SENSITIVE TO LIGHT



ROOTS GROW TOWARDS WATER



ROOTS GROW TOWARDS THE EARTH



MAKING A CARROT "FERN"

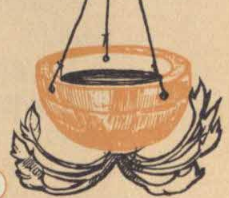
①

②

③

④

⑤



⑥

1. Use a knife to cut off the pointed end of a carrot.
2. Scoop out the centre of the carrot.
3. Use a needle to make 3 holes in the carrot.
4. Thread cotton through the 3 holes.
5. Fill the carrot with water and hang it up.
6. The leaves grow and push upwards. Why?

36 Plants without flowers

The plant kingdom

The plant kingdom can be divided into two kinds of plants – the *flowering* and the *non-flowering*.

The non-flowering plants are the *ferns, mosses, fungi* and *algae* (pronounced "al-gee").

Ferns

Ferns have roots, stems and leaves. The stem of a fern is swollen and grows just below the surface of the soil. The leaves are called *fronds*.

Mosses

Mosses have stems and leaves but no roots. At the bottoms of their stems, mosses have thread-like growths which do the work of roots.

Fungi

Fungi are simple plants without roots, stems and leaves. They are not green. Mushrooms and toadstools are fungi. Fungi grow very quickly. They feed on plant and animal materials, such as manure and dead leaves. Perhaps, you have seen a *bracket fungus* growing on a tree trunk. *Moulds*, which grow on jam, cheese, bread, etc., are fungi also.

Algae

Algae are also simple plants without roots, stems and leaves.

Seaweeds are algae. They have various colours – green, yellow, brown and red.

The green scum on the sides of ponds and aquarium tanks and the green powdery patches on damp stones and tree trunks are many tiny algae.

Spores

Flowering plants grow from seeds, but most of the non-flowering plants grow from *spores*. Spores are very tiny.

There are brown spots on the undersides of fern fronds. These brown spots are "*spore-boxes*". When they are ripe, they burst open and the spores inside them are thrown out. The spores begin to grow when they meet moist soil.

Mosses have "spore-boxes" on the tips of some of their stems.

On the underside of the cap of a mushroom, there are black "*gills*" which shed spores.

Some non-flowering plants

Examine a mushroom, any fern and any moss, if they are available. These are the things to look for.

Mushroom: colour, shape and "gills".

Fern: roots, stem, fronds and "spore-boxes".

Moss: stems, leaves, "root" growths and "spore-boxes".

Growing moulds

Moisten a slice of bread and place it on a dish. Stand it in a warm place. Mould spores in the atmosphere fall on the bread and begin to grow.

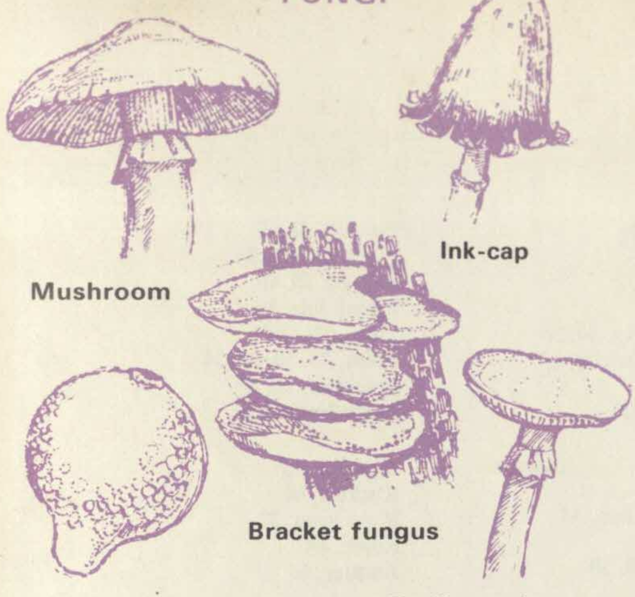
After a week or so, examine the moulds under a magnifying glass.

You will see masses of white threads and some black "spore-boxes" which, when they are ripe, will burst open and throw out their spores.

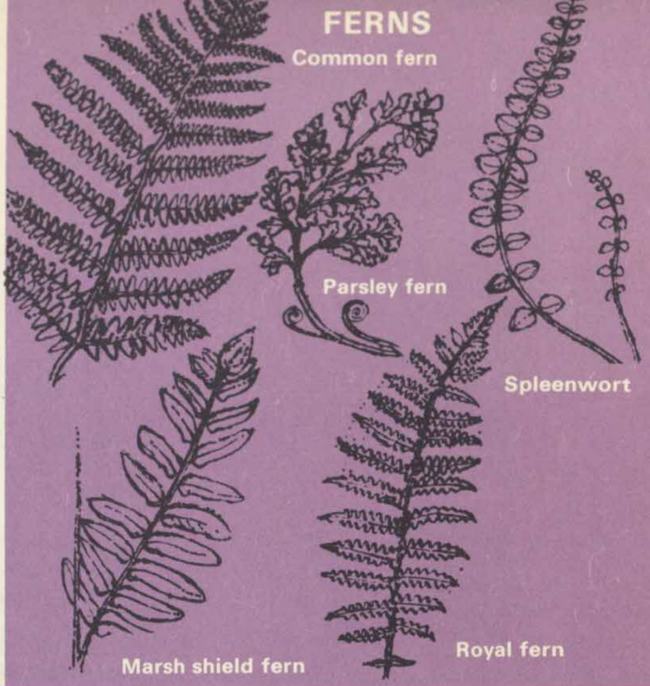
MORE THINGS TO DO

1. Make free-hand drawings of some of the fungi and ferns shown opposite. Print their names below them.
2. Draw a moss. An easy way to do this is shown opposite.
3. Write a few sentences about spores.

FUNGI

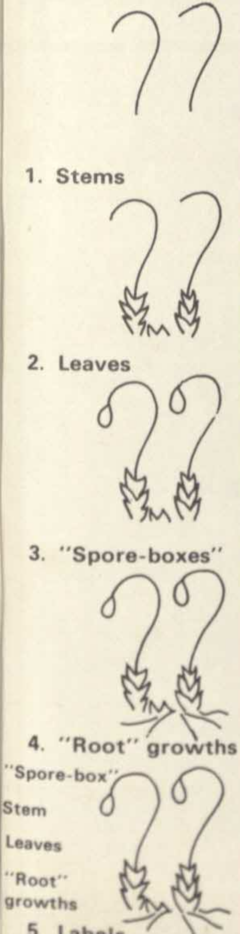


FERNS



Plants without flowers

DRAWING A MOSS



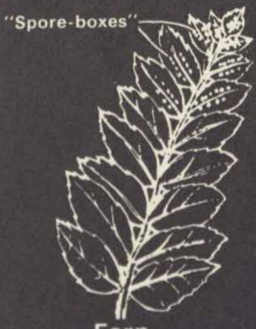
ALGAE

On a tree trunk

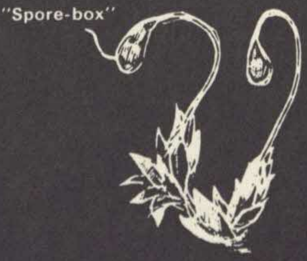
On a stone

Seaweed

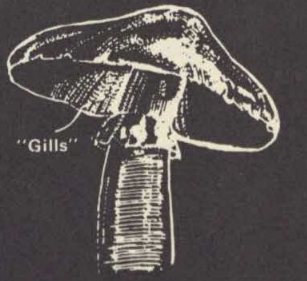
SPORES



Fern

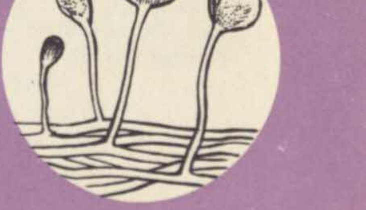


Moss



Mushroom

GROWING MOULDS



Index

Aeroplanes, 62, 64
Ailerons, 66
Air resistance, 62
Airscrews, 62
Airships, 64
Algae, 78
Amphibians, 50
Asteroids, 42
Astronauts, 46

Balances, 56
Balloons, 64
Batteries, 12, 14
Broad bean, 72

Candle clock, 48
Carrot "fern", 76
Centre of gravity, 58
Centrifugal force, 54
Cleopatra's Needle, 48
Clocks, 48
Cold-blooded animals, 50
Compass, 32, 40
Conductors, 16, 22
Constellations, 38
Constellation viewer, 38
Copper-plating, 24

Earth, 42, 44, 46, 58, 60
Earthing, 22
Earthworm, 70
Eclipses, 44, 46
Egg-timer, 48
Electric bell, 36
Electric cells, 12
Electric charges, 8
Electric current, 14
Electric fire, 20
Electric iron, 20
Electricity, 8, 10, 12, 14, 16, 18, 20, 22
Electric kettle, 20
Electric pressure, 14
Electric shocks, 22
Electro-magnets, 34, 36
Electrolysis, 24
Electro-plating, 24
Electro-typer, 26
Electroscope, 10
Elevators, 66
Evening Star, 42

Fairy lamps, 26
Ferns, 78
Fishes, 50
Flight, 62
Force of gravity, 54, 56
Frictional electricity, 10
Frog, 52
Frog spawn, 52
Fronds, 78
Fungi, 78

Germination tests, 74
Gliders, 62, 66
Gravity, 54, 56, 58

Helicopters, 64
Hour-glass, 48
House lighting, 26
Humus, 68

Illuminated sign, 26
Insulators, 16

Jet engine, 62, 64
Jupiter, 42

Kite, 62

Lamps, 18
Lift, 62
Lightning, 8
Lightning conductors, 8
Lunik, 46

Magnetic fields, 30
Magnetic mines, 32
Magnetic toys, 32
Magnets, 28, 30, 32, 34, 36
Mars, 42
Mercury, 42
Milky Way, 38
Model glider, 62, 66
Months, 46
Moon, 44, 46, 56
Moon's phases, 46
Morning Star, 42
Mosses, 78
Moulds, 78

Navigation, 40
Neptune, 42

Orbits, 42, 46, 54, 60

Planets, 42, 60
Plant growth, 76
Plough, 38, 40
Plumb-line, 54
Pluto, 42
Poles, 25, 30, 32, 34
Pole Star, 38, 40
Propellers, 62, 64

Reptiles, 50
Rockets, 60
Root hairs, 72
Rotor, 64
Rudder, 66

Safety-switch, 22
Satellites, 60
Saturn, 42
Scales, 56
Seaweeds, 78
Seeds, 72, 74
Shadow clock, 48
Shadows, 44, 48
Sirius, 38
Solar system, 42
Soil, 68, 70
Southern Cross, 40
Spores, 78
Spring balance, 56
Stars, 38, 40
Streamlining, 60
Subsoil, 68, 70
Sun, 40, 44, 48
Sundial, 48

Tadpoles, 52
Thermostat, 20
Thunder, 8
Time, 48
Torch, 18
Two-way switching, 18

Uranus, 42

Venus, 42
Vivarium, 50
Voltage, 14

Water clock, 48
Weathering, 68
Weight, 56
Wormery, 70